A11100 989725

NAT'L INST OF STANDARDS & TECH R.I.C.
A11100989725
/NBS monograph
QC100 .U556 V101;1967 C.2 NBS-PUB-C 1959

NBS
PUBLICATIONS

NBS MONOGRAPH 101

Low Temperature Mechanical Properties Of Copper and Selected Copper Alloys

A Compilation From the Literature

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

UNITED STATES DEPARTMENT OF COMMERCE

Alexander B. Trowbridge, *Secretary*

NATIONAL BUREAU OF STANDARDS ● A. V. Astin, *Director*

Low Temperature Mechanical Properties Of Copper and Selected Copper Alloys

A Compilation From the Literature

Richard P. Reed and Ritchie P. Mikesell

Institute for Materials Research
National Bureau of Standards
Boulder, Colorado 80302

U. S. National Bureau of Standards, Monograph 101

Issued December 1, 1967

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $2.75

National Bureau of Standards
SEP 3 1968
141779
QC100
.U556
No.101
1967
Copy 3.

Contents

Library of Congress Catalog Card Number: 67-60379

Low-Temperature Mechanical Properties of Copper and Selected Copper Alloys

A Compilation From the Literature

R. P. Reed and R. P. Mikesell

In the past 60 years considerable data has accumulated concerning the mechanical properties of copper and its alloys. It was felt that there was a great need to adequately document these results in one publication. Therefore a unique type of compilation is presented. The compilation is divided into four parts. The first section is intended for quick reference use for those who are interested in average values. The second section includes data from most of the investigators who have published results on the mechanical properties of copper and its alloys. The third section is composed of tables classifying the investigations which were not included in section two. These usually involve investigations in which data were obtained only at one temperature, such as room temperature. The fourth section lists, in alphabetical order, all references used.

Key words: compilation, copper, copper alloys, low temperature, mechanical properties.

Introduction

In the past 60 years considerable data have been accumulated concerning the mechanical properties of copper and its alloys. Earlier investigations were primarily concerned with hardness, tensile strength, creep, and fatigue of copper at ambient temperatures and above. Gradually, with the introduction of new alloys and low temperature testing techniques, the scope of materials, temperature, and type of tests has broadened. However, it is not possible to find in one publication an adequate and thorough compilation concerning the mechanical properties of copper alloys. It was felt that the need for such a publication was great. With this in mind, we are grateful to the International Copper Research Association (INCRA) and to the Copper Development Association for funding this compilation.

The selection of the alloys was based on INCRA advice. They include pure copper plus some of the common solid solution copper alloys (copper-zinc, copper-nickel, copper-aluminum) and some age-hardened alloys (aluminum bronzes, copper silicon, copper-zirconium). The only major alloy group which was omitted but perhaps should have been included is the copper-beryllium series. However, this group was included in the Cryogenic Materials Data Handbook,* and the reader is advised to refer to this publication to obtain references and average properties for copper-beryllium alloys.

The compilation is divided into four sections. Section I is intended for quick reference use for those who are interested in average values. Section II includes data from most of the investigators who have published results on the mechanical properties of copper and its alloys. Section III is composed of tables classifying the investigations which were not included in Section II. These usually involve investigations in which data were obtained only at one temperature, such as room temperature. Section IV lists, in alphabetical order, all references used in this compilation. The preceeding paragraphs serve to document the procedures followed in this compilation.

The average values, plotted on pages 2 to 13 are estimated from the curves of Section II. Common material conditions for which data are available are included. However, in cases where it was thought that the data may not be representative or where only scattered, possibly unreliable data points are available, then that particular alloy or condition or temperature region was omitted.

Section II includes all available mechanical property data for the selected alloys with two exceptions. If investigators included only single temperature data (such as room temperature) and not time-dependent curves (such as stress-strain, fatigue, or creep) then the data were not included. Investigations of this nature which usually document trends of tensile properties or hardness as a function of metallurgical variables, such as grain size or irradiation, are listed in the tables of Section III. Some experimental data, particularly those obtained from single crystals, were not included in Section II. These data usually represent the results of flow stress, microstrain, or elastic constant experimental work. All references of Sections II and III are included in Section IV. In Section II the table adjacent to each graph lists all pertinent experimental and material information. If experimental or material details are omitted, it is because the information was not available in the reference. All individual temperature data points are plotted. However, the point at each temperature represents an average of the individual tests performed at the given temperature. Creep and fatigue curves for a given temperature are average curves. Stress-strain curves were only included if the stress and strain were continuously recorded to fracture. Again, it seems appropriate to emphasize that if information is lacking on either the tables or the graphs, it may be assumed that the reference has failed to include it.

Considerable effort was made to present all of the usable data from the literature. Articles as early as 1895 are included. No data, regardless of its suspected reliability, were deliberately omitted. All temperature points are included even though some of them are probably in error. Great importance was placed in presenting all of the data in Section II, so that an informed observer could use his own discretion in evaluating the data. Part of the program sponsored by INCRA included tensile, notch tensile, and elastic modulus tests from 300 to 4 °K and impact tests from 300 to 20 °K. The results of this test program are referenced in Section II under reference number 1.

Many papers included reliable data on copper and its alloys which did not fall within the scope of the compilation. It was felt that these articles should be included in the bibliography and somehow referenced. The tables in Section III are the result. By referral to these, the reader may note the articles in which specific tests have been performed on a given alloy series. It is thought that these reference tables will also be valuable to the reader in describing the various tests that have been performed on a specific alloy. Similarly, knowledge may be obtained regarding the investigations of specific metallurgical parameters (such as irradiation on a given alloy or alloy series). About 30 review papers are included in the references and are listed in the table on page 144. Discretion was used in choosing these papers, since many more exist in published form, particularly in trade journals. In a few cases, data were taken directly from a review paper, since the source of the data could not be adequately located nor referenced.

Over 700 individual papers were examined and data were selected from the 465 references listed in Section IV. We

*Obtained through Office of Technical Services, U.S. Department of Commerce, Washington, D.C., designated PB 171809.

have undoubtedly missed some pertinent references, however it is hoped that these omissions are minimal.

Finally, for a publication of this magnitude, many others have taken part. The authors wish to thank L. Berenbaum and W. Hawkesworth who have helped in the preparation of the tables and graphs. Mrs. L. Cottony provided valuable assistance in the procurement of over 700 papers which were examined in this Monograph. The authors wish to express their gratitude to L. Ericks, who was responsible for the majority of the figure drafting, and to Mrs. C. Dallman, who performed most of the typing. Also, as previously stated, the authors are indebted to the International Copper Research Association, who have provided the necessary funds for the performance of this program.

List of Abbreviations

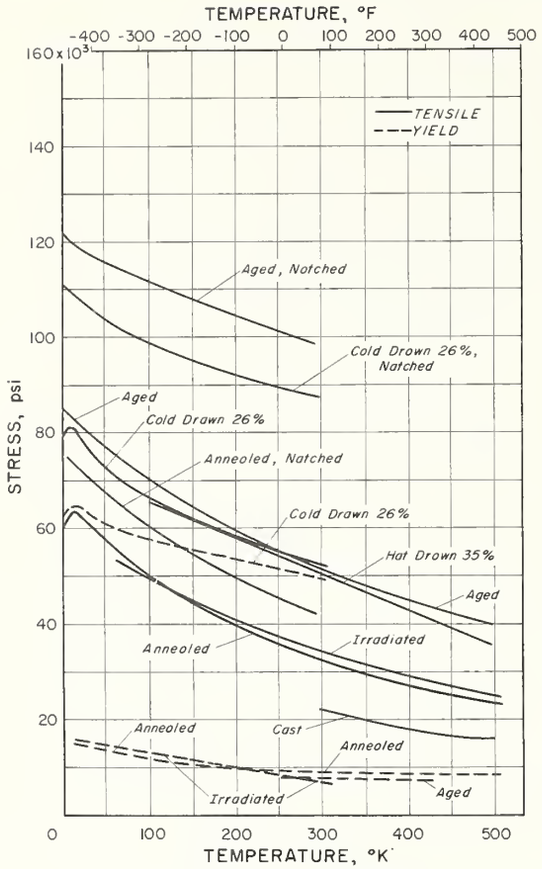
ASTM	American Society for Testing Materials
approx.	approximately
atmos.	atmosphere
Bal.	balance
°C	degrees Celsius (centigrade)
c.p.m.	cycles per minute
c.p.s.	cycles per second
diam.	diameter
°F	degrees Fahrenheit
ft	foot, feet
ft-lb	foot-pound
G.L.	gage length
gm	gram
G.S.	grain size
hr	hour
°K	degrees Kelvin
Kc.p.s.	kilocycles per second
kgm	kilogram
K_T	stress concentration factor $= \sqrt{\frac{\text{½ distance between notches}}{\text{notch radius}}}$
Mc.p.s.	megacycle per second
mm	millimeters
nvt	integrated flux $\left(\frac{\#}{\text{cm}^2}\right)$
psi	pounds per square inch
R	ratio of applied minimum to maximum stress in fatigue tests
r.p.m.	revolutions per minute
$R_{(x)}$	Rockwell hardness number, scale (x)
sec.	second
temp.	temperature
U.T.S.	ultimate tensile strength
Y.S.	yield strength

Section I

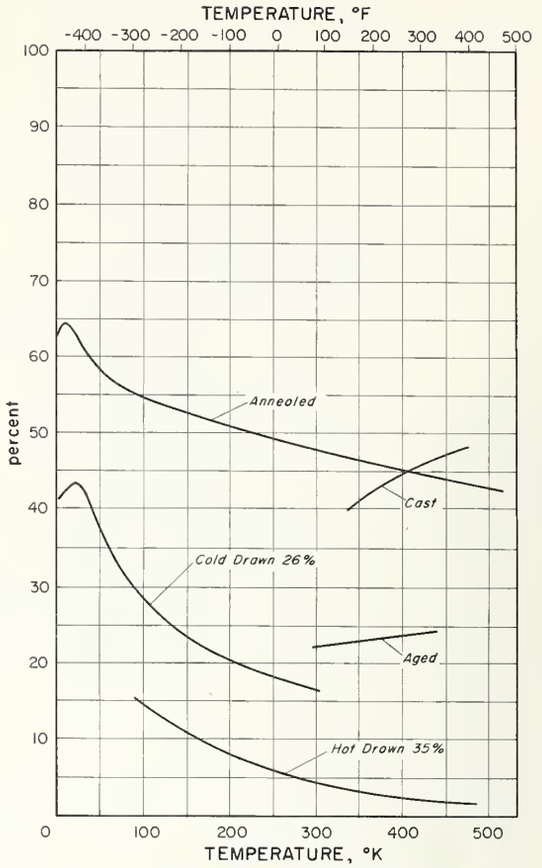
In this section average values, taken from all investigations used in Sections II and III, are plotted. This is intended for quick reference.

Contents

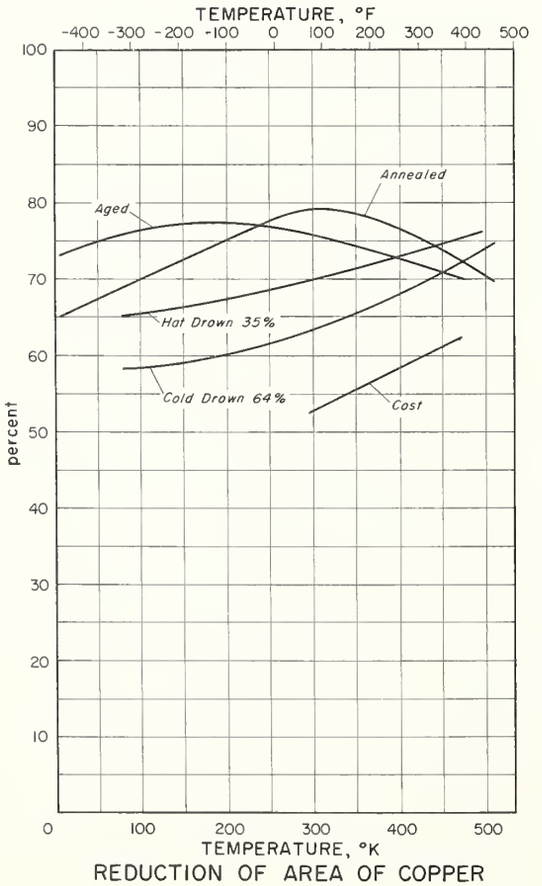
Mechanical Properties of Copper



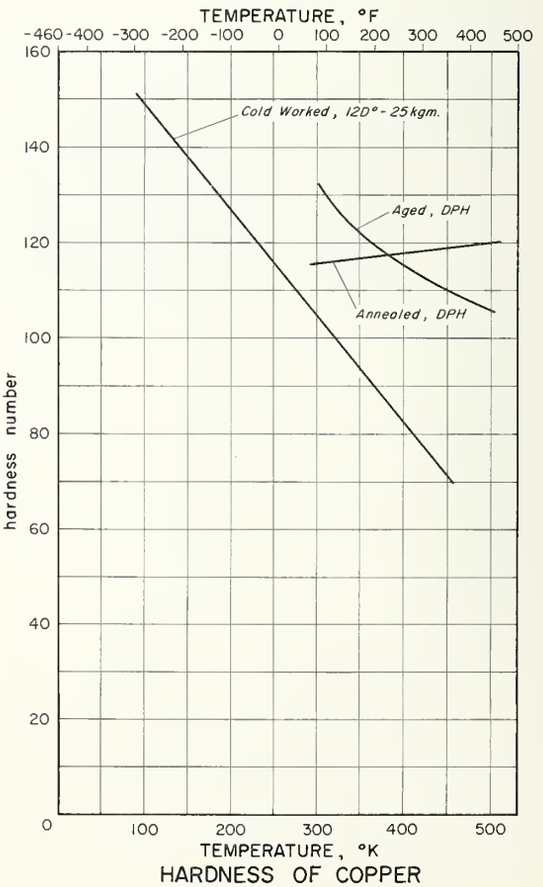
STRENGTH OF COPPER



ELONGATION OF COPPER

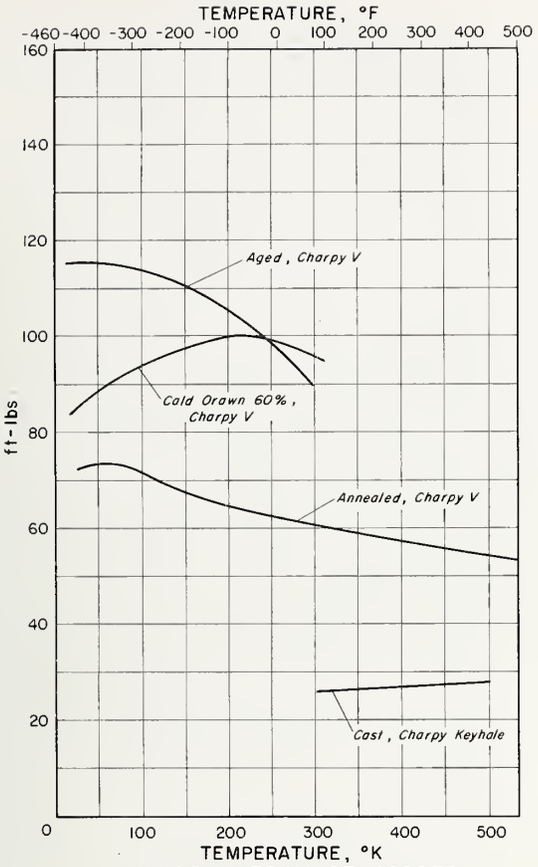


REDUCTION OF AREA OF COPPER

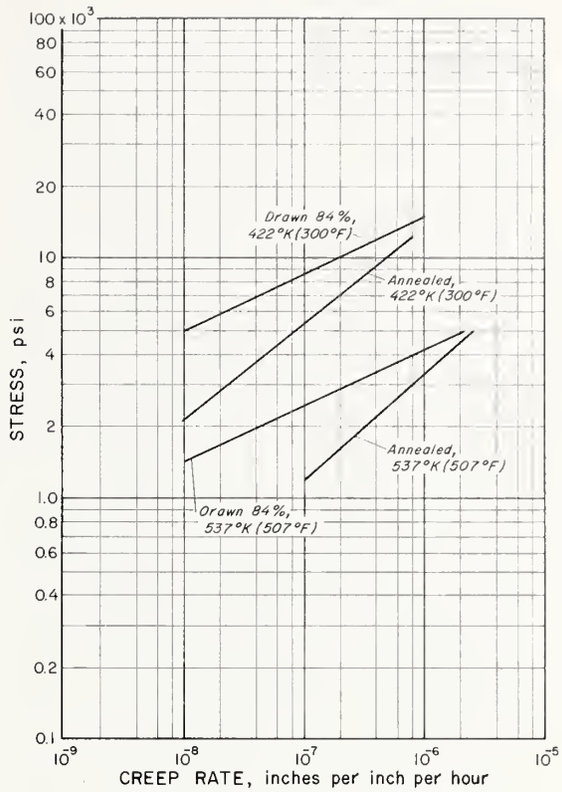


HARDNESS OF COPPER

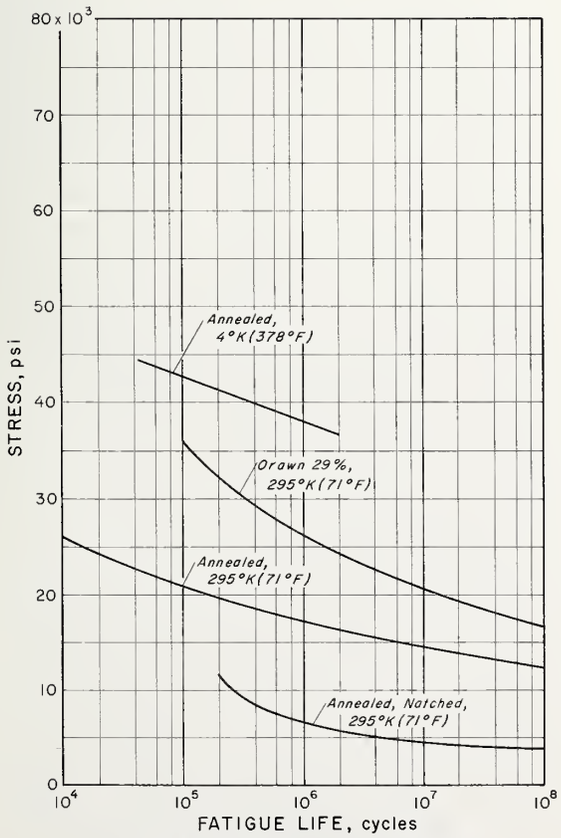
Mechanical Properties of Copper



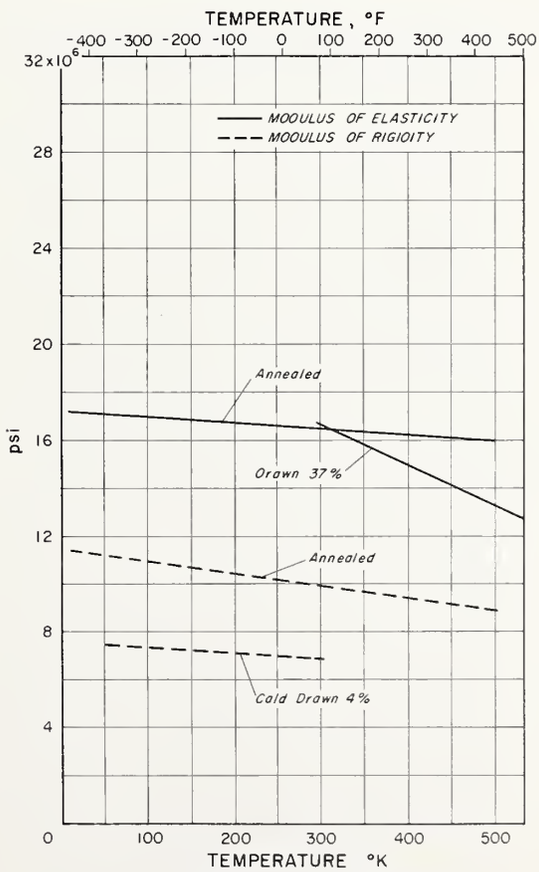
IMPACT ENERGY OF COPPER



CREEP BEHAVIOR OF COPPER

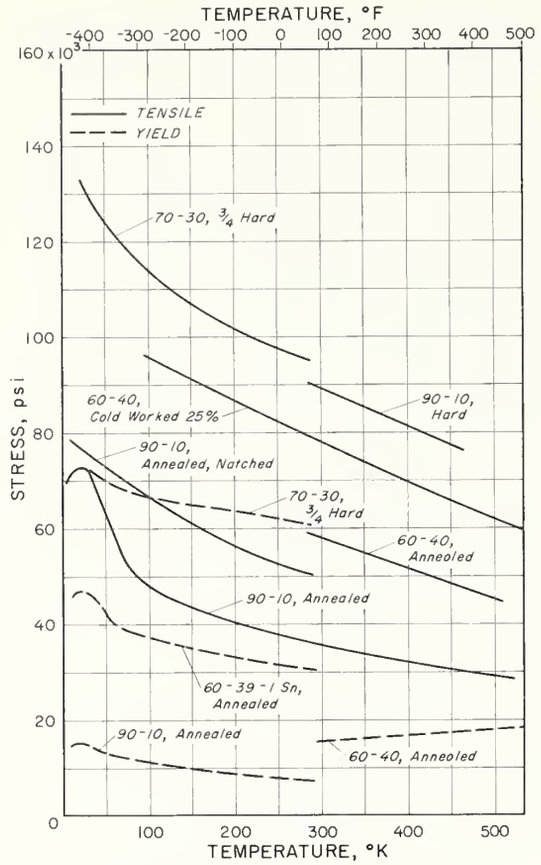


FATIGUE BEHAVIOR OF COPPER

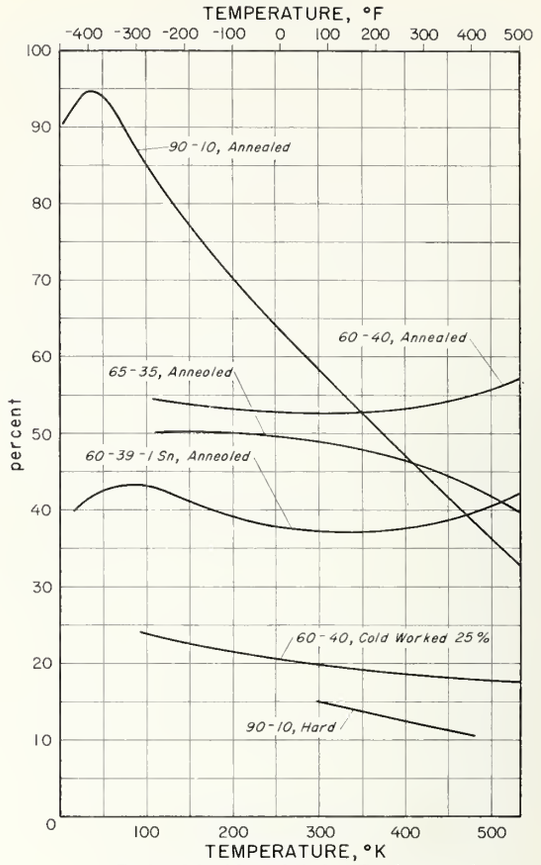


MODULUS OF COPPER

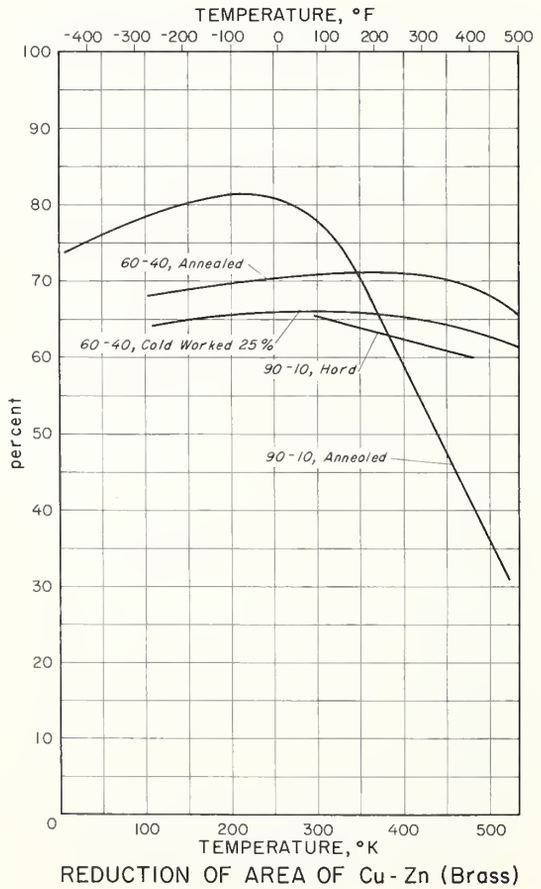
Mechanical Properties of Cu-Zn (Brass)



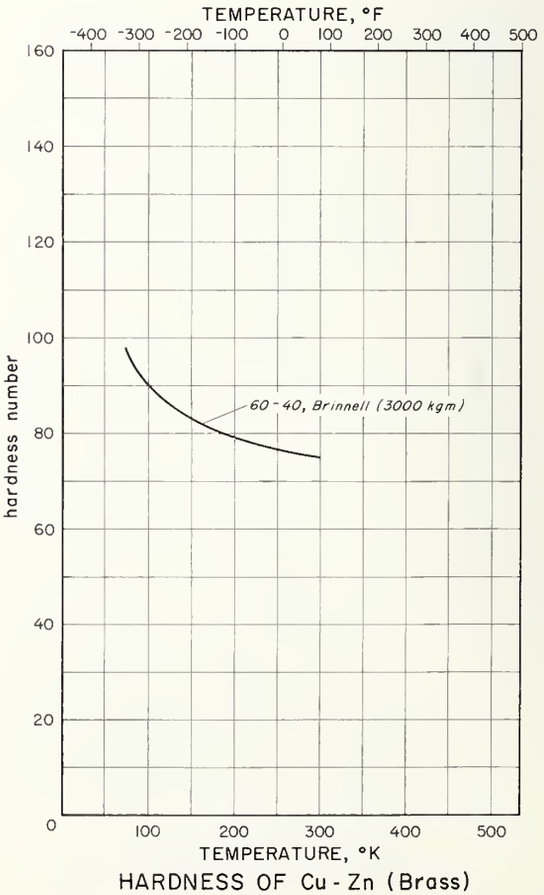
STRENGTH OF Cu-Zn (Brass)



ELONGATION OF Cu-Zn (Brass)

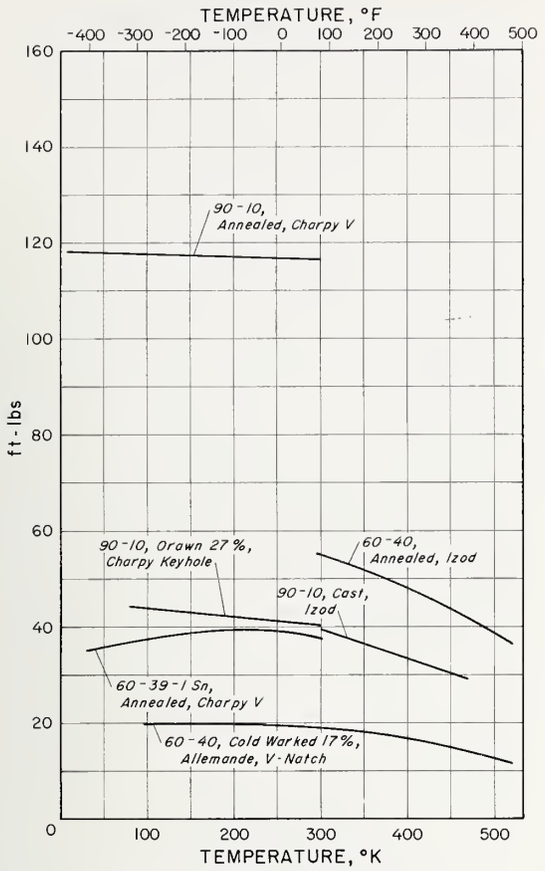


REDUCTION OF AREA OF Cu-Zn (Brass)

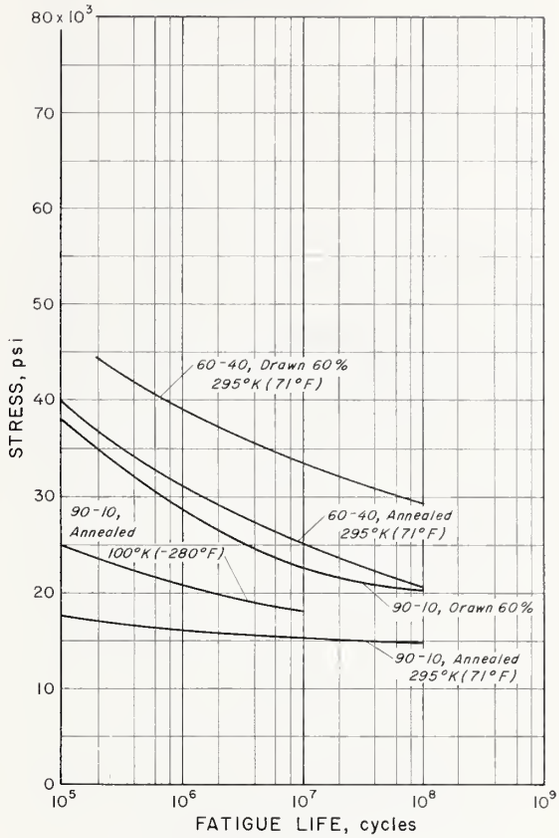


HARDNESS OF Cu-Zn (Brass)

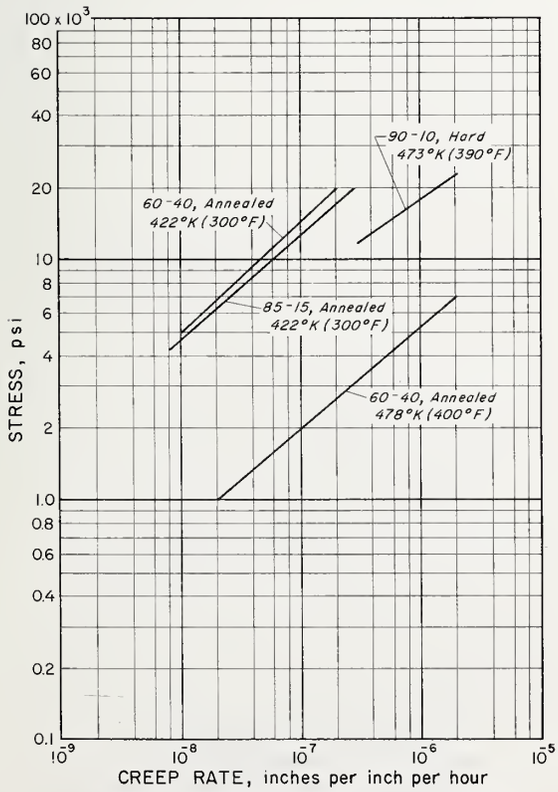
Mechanical Properties of Cu-Zn (Brass)



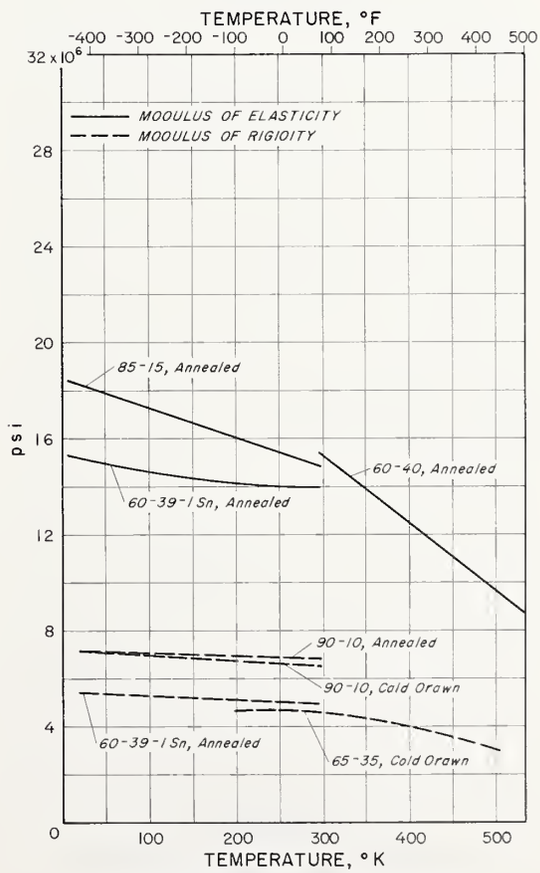
IMPACT ENERGY OF Cu-Zn (Brass)



FATIGUE BEHAVIOR OF Cu-Zn (Brass)

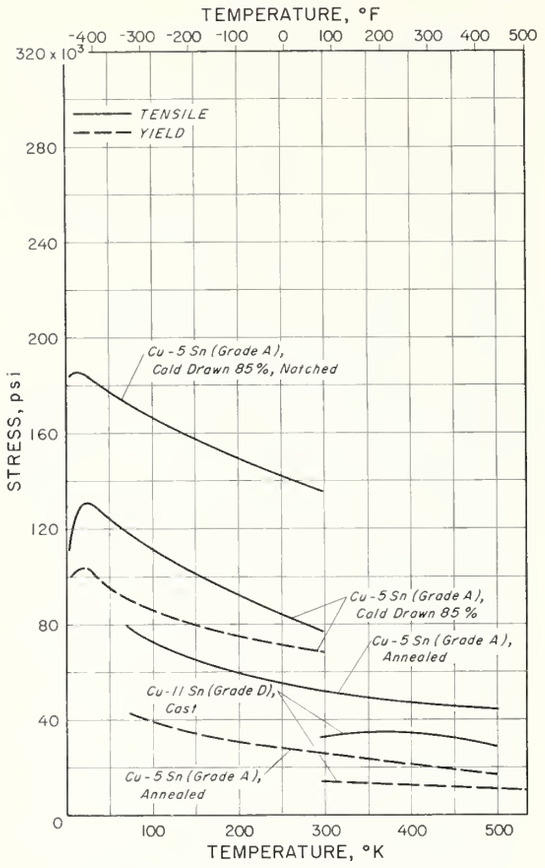


CREEP BEHAVIOR OF Cu-Zn (Brass)

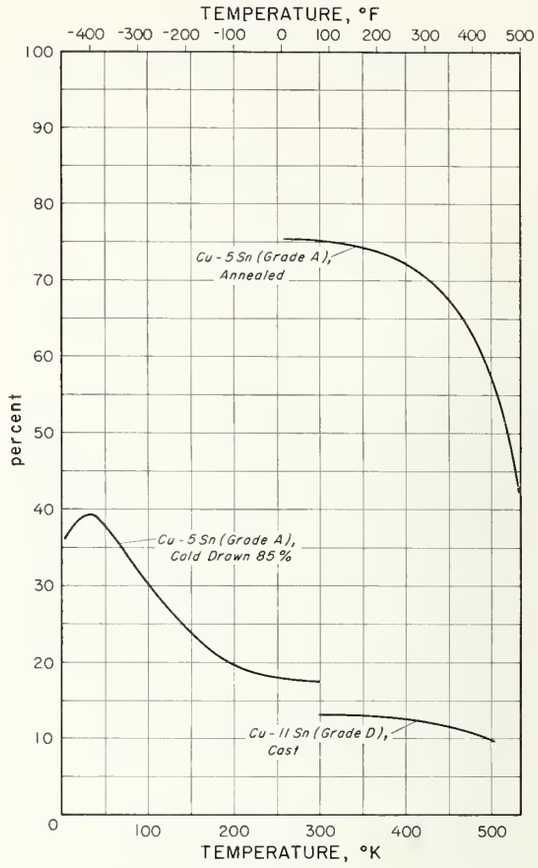


MODULUS OF Cu-Zn (Brass)

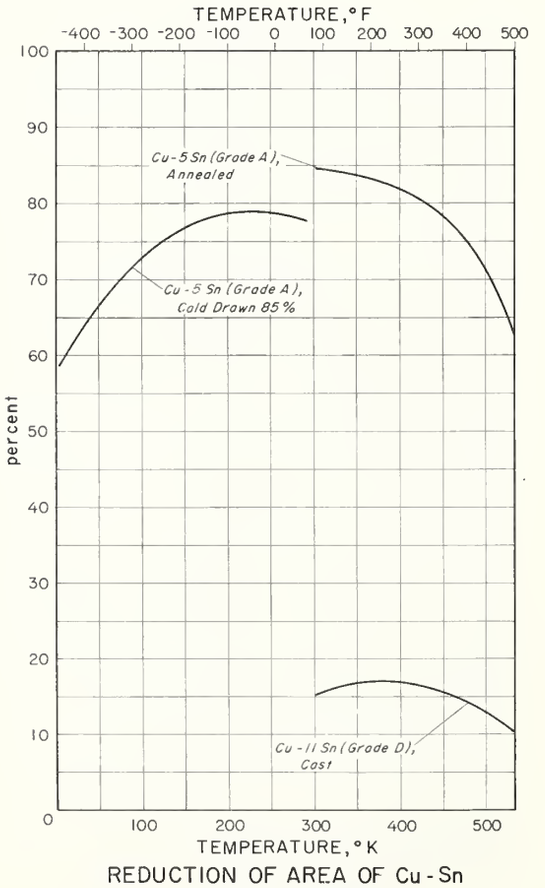
Mechanical Properties of Cu-Sn (Phosphor Bronze)



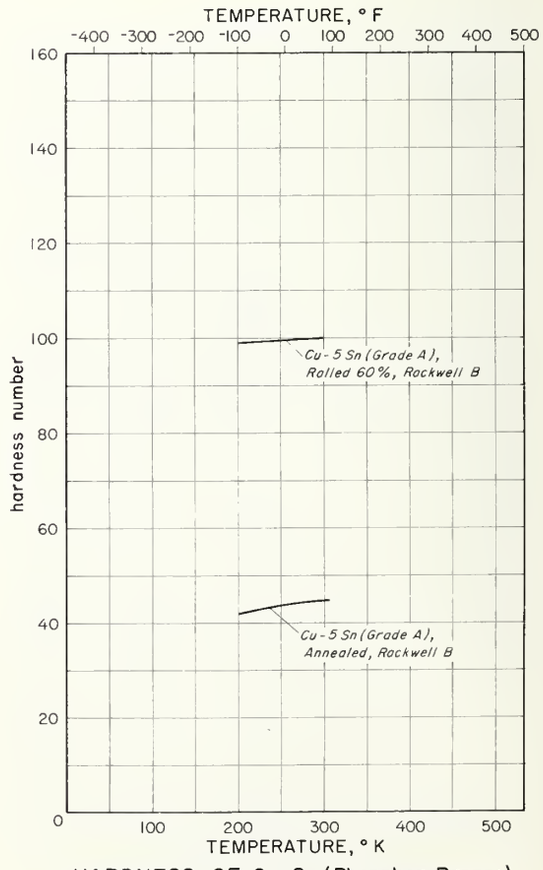
STRENGTH OF Cu-Sn (Phosphor Bronze)



ELONGATION OF Cu-Sn (Phosphor Bronze)

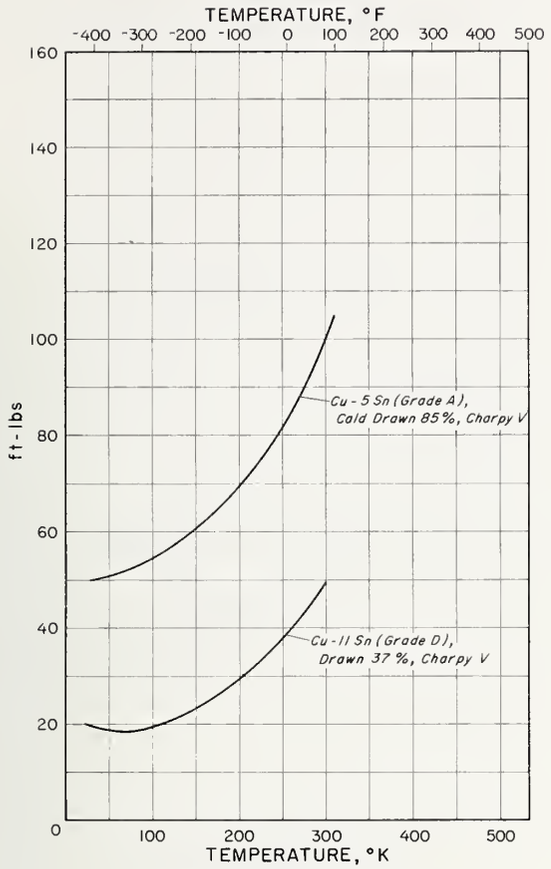


REDUCTION OF AREA OF Cu-Sn (Phosphor Bronze)

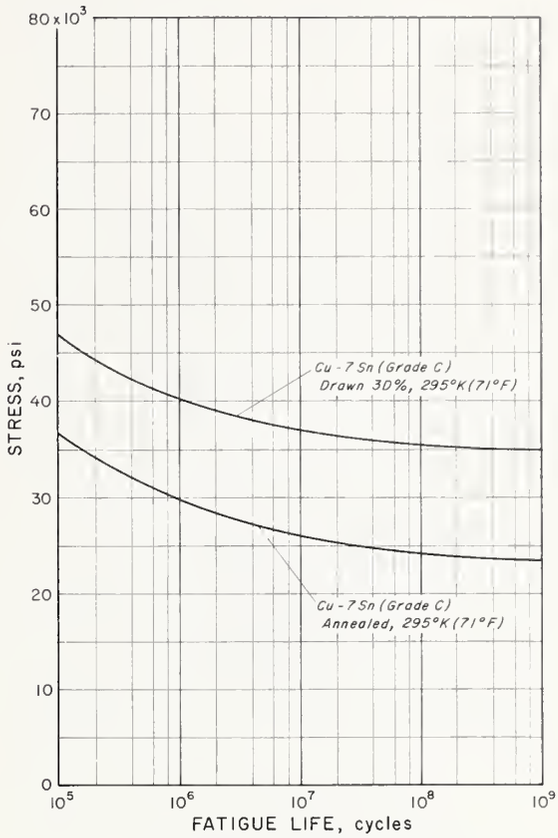


HARDNESS OF Cu-Sn (Phosphor Bronze)

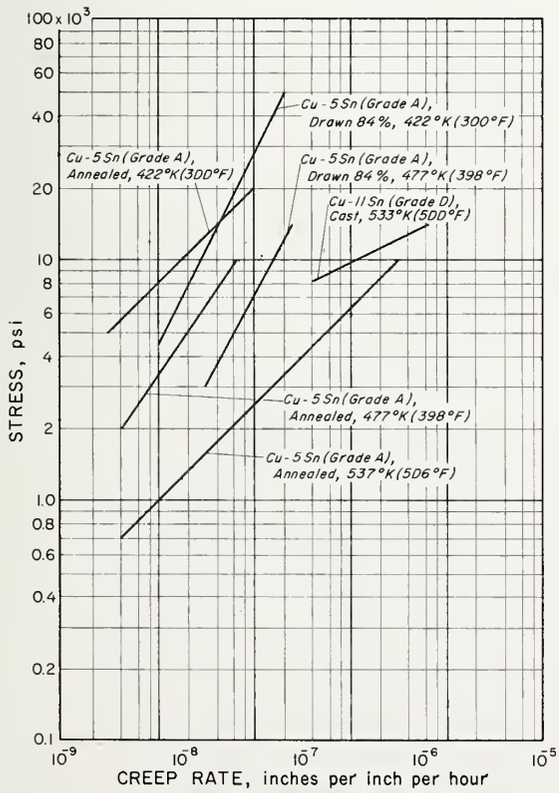
Mechanical Properties of Cu-Sn (Phosphor Bronze)



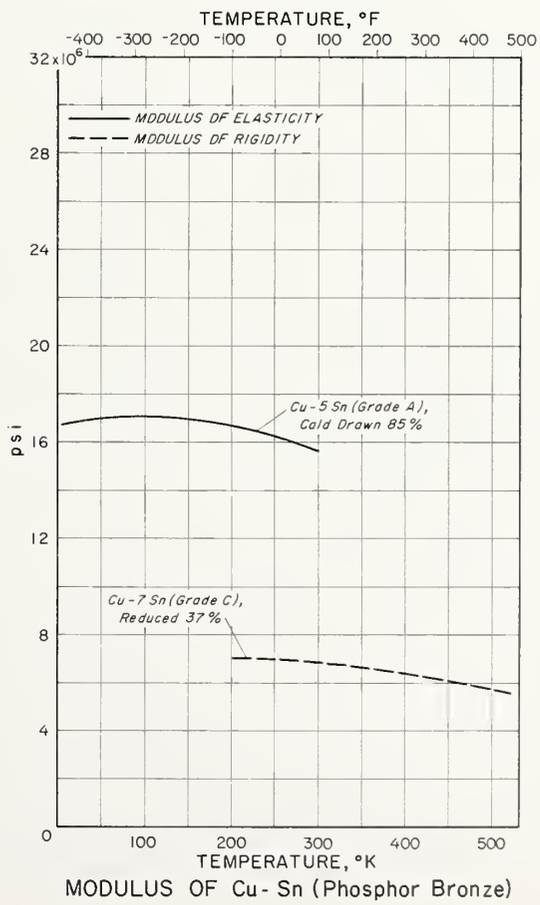
IMPACT ENERGY OF Cu-Sn
(Phosphor Bronze)



FATIGUE BEHAVIOR OF Cu-Sn
(Phosphor Bronze)

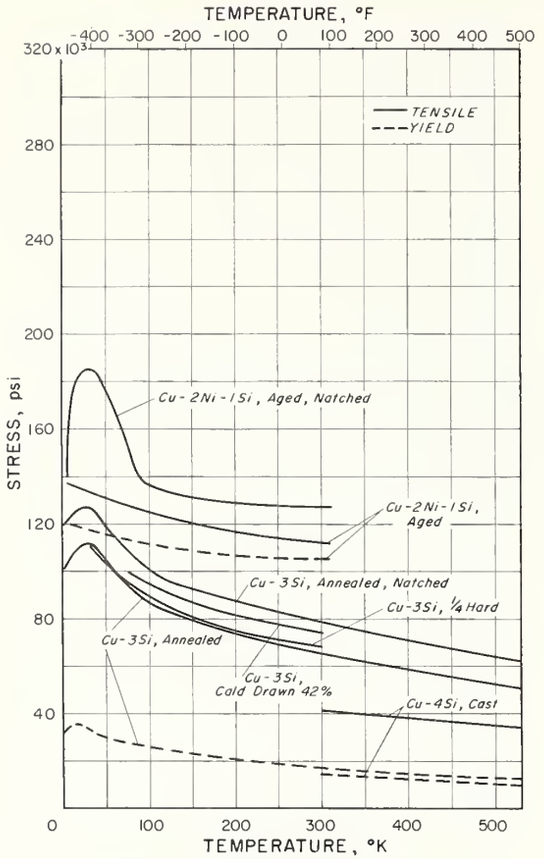


CREEP BEHAVIOR OF Cu-Sn
(Phosphor Bronze)

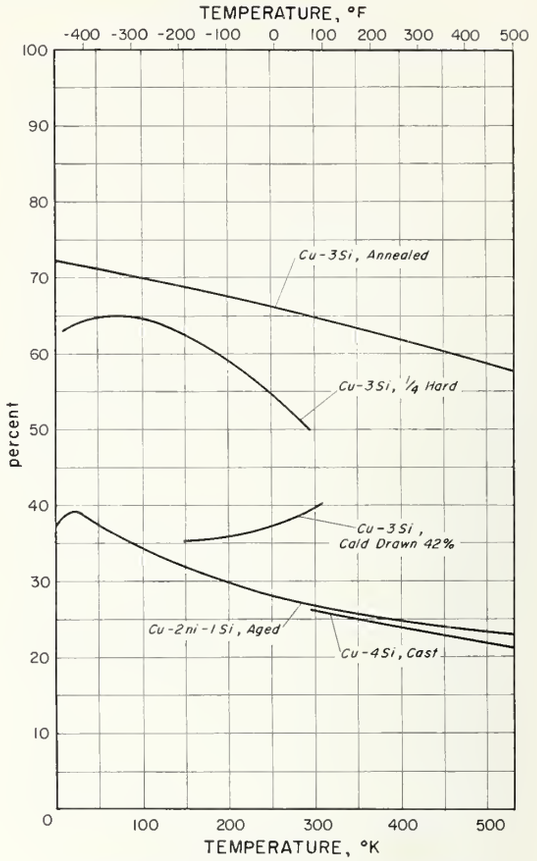


MODULUS OF Cu-Sn (Phosphor Bronze)

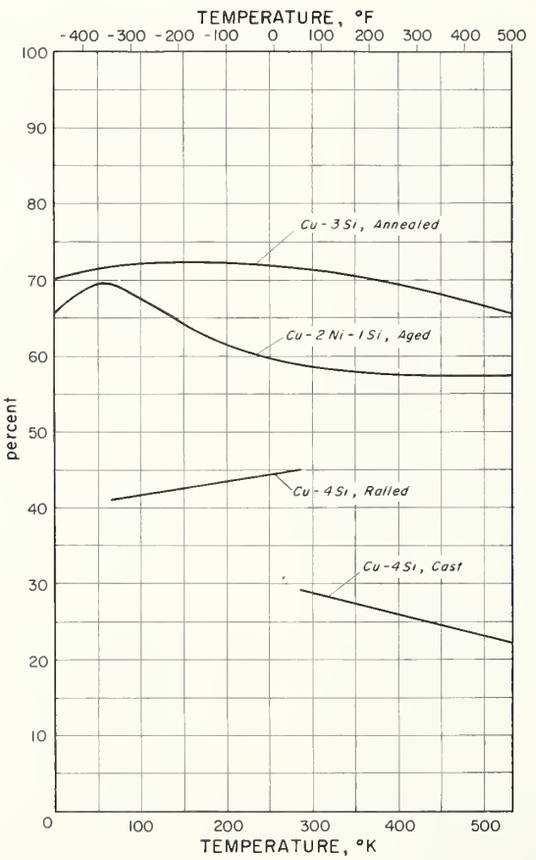
Mechanical Properties of Cu-Si (Silicon Bronze) and Cu-Ni-Si



STRENGTH OF Cu-Si (Silicon Bronze) AND Cu-Ni-Si

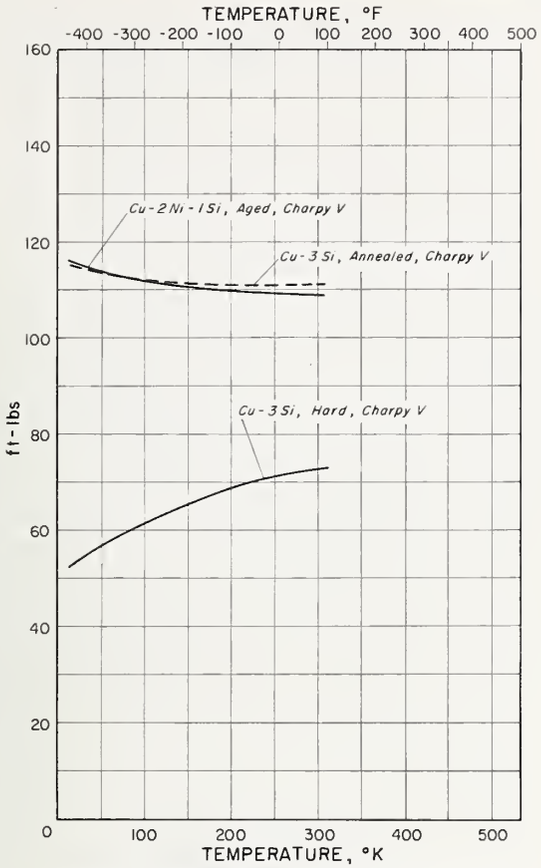


ELONGATION OF Cu-Si (Silicon Bronze) AND Cu-Ni-Si

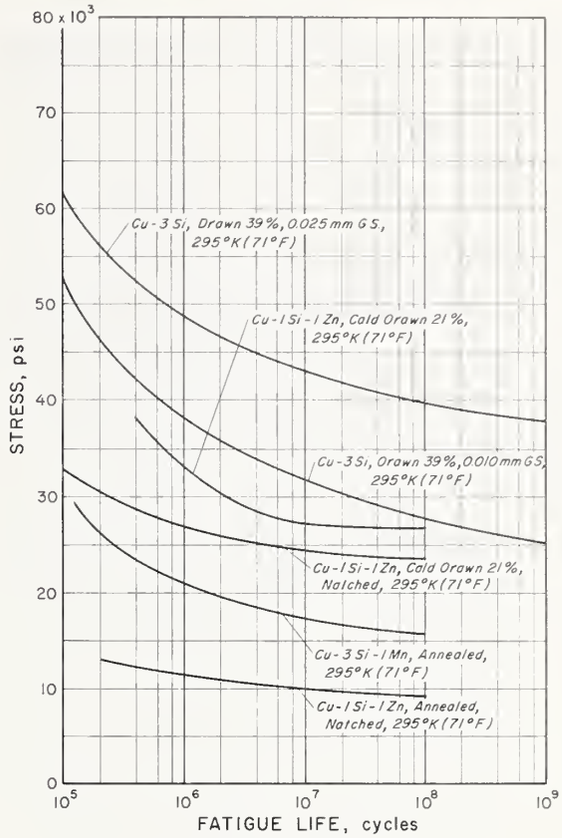


REDUCTION OF AREA OF Cu-Si (Silicon Bronze) AND Cu-Ni-Si

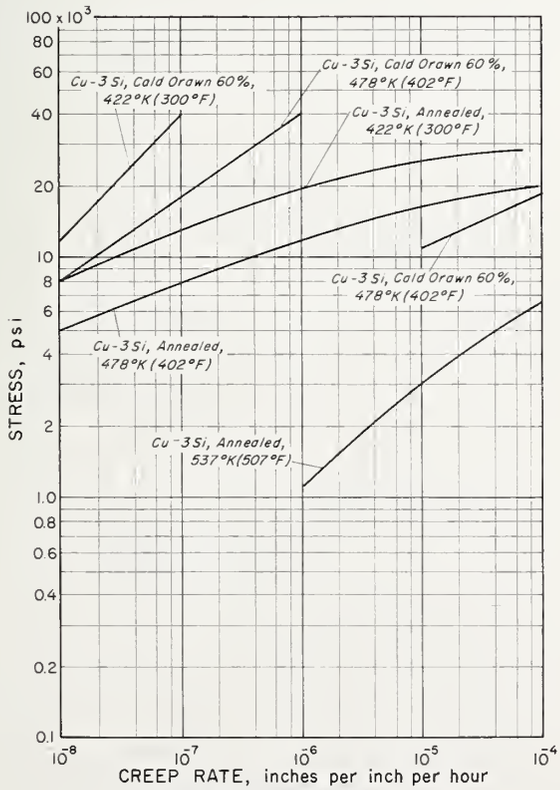
Mechanical Properties of Cu-Si (Silicon Bronze) and Cu-Ni-Si



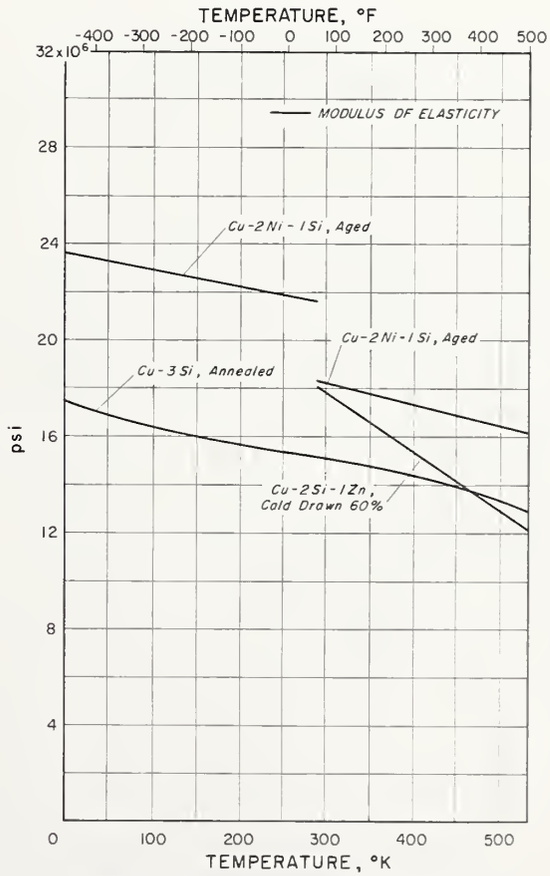
IMPACT ENERGY OF Cu-Si (Silicon Bronze) AND Cu-Ni-Si



FATIGUE BEHAVIOR OF Cu-Si (Silicon Bronze) and Cu-Ni-Si

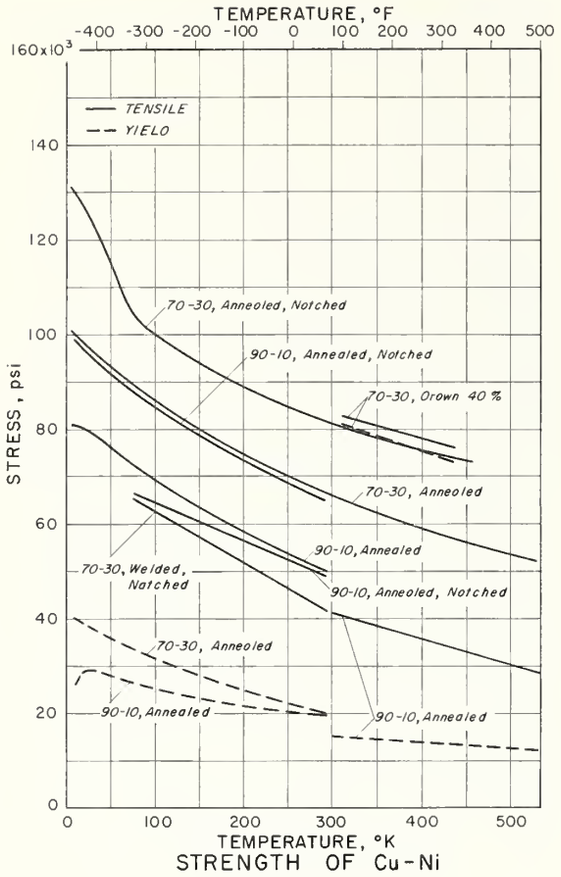


CREEP BEHAVIOR OF Cu-Si (Silicon Bronze) and Cu-Ni-Si

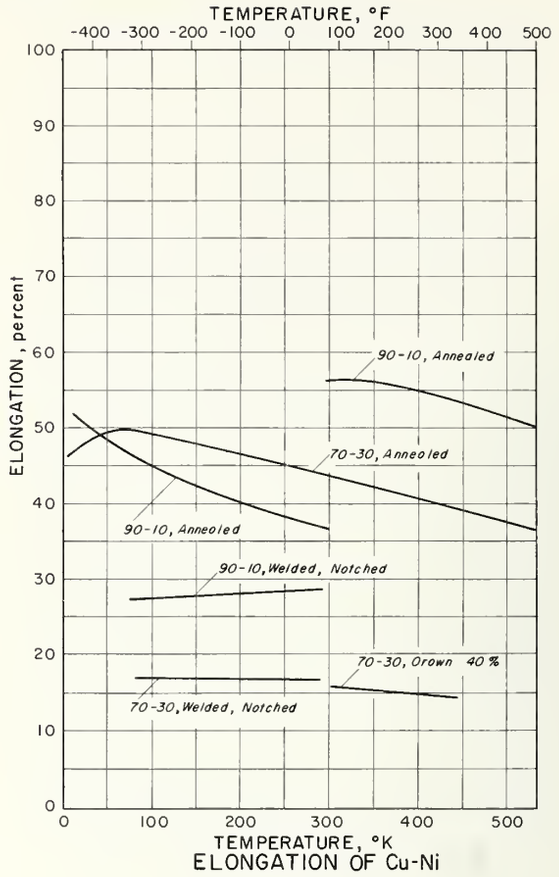


MODULUS OF Cu-Si (Silicon Bronze) AND Cu-Ni-Si

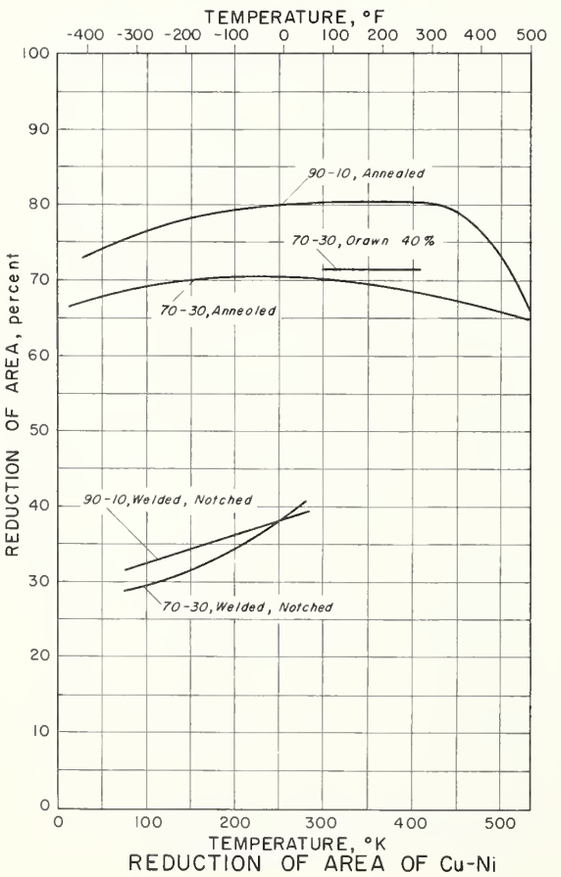
Mechanical Properties of Cu-Ni



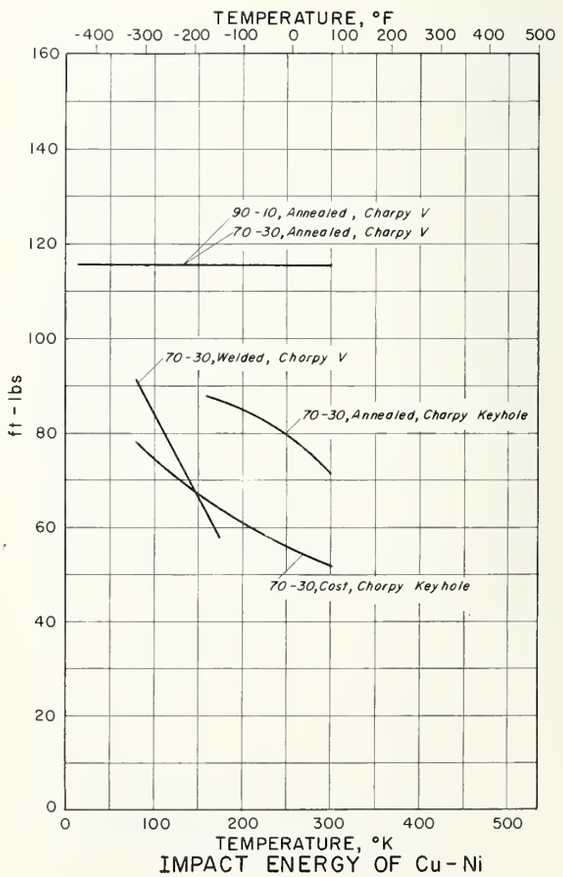
STRENGTH OF Cu-Ni



ELONGATION OF Cu-Ni

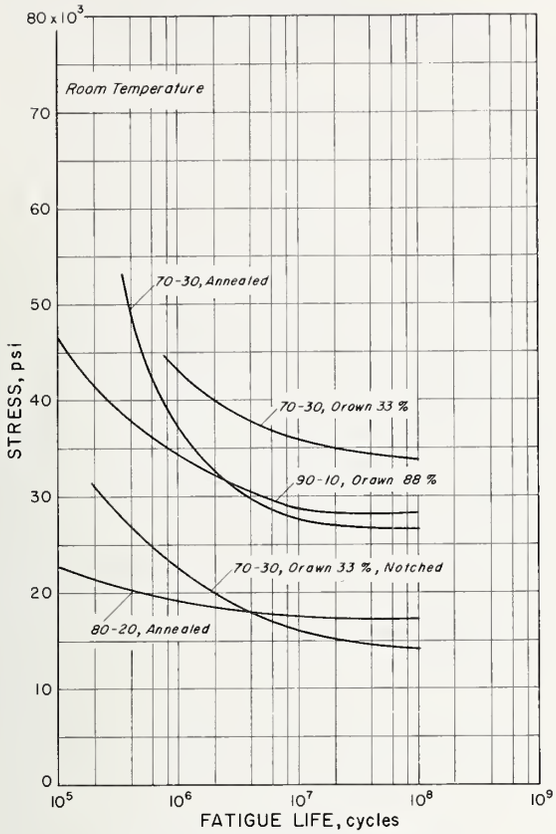


REDUCTION OF AREA OF Cu-Ni

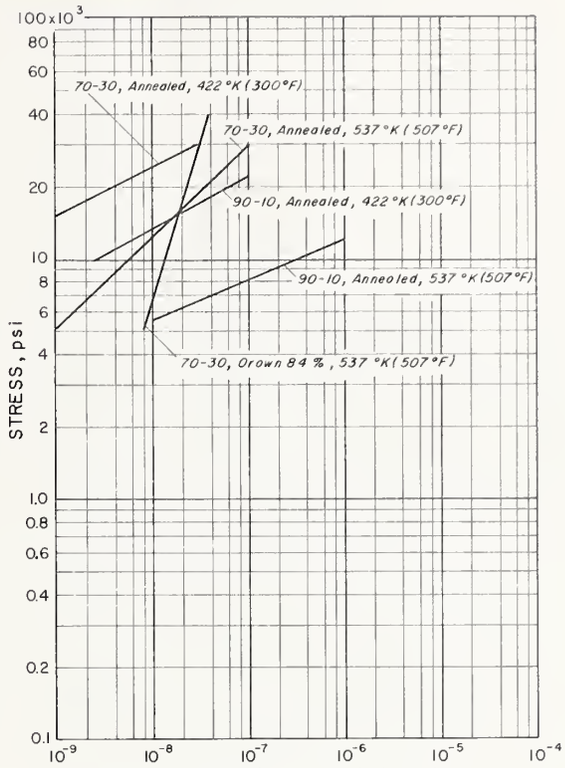


IMPACT ENERGY OF Cu-Ni

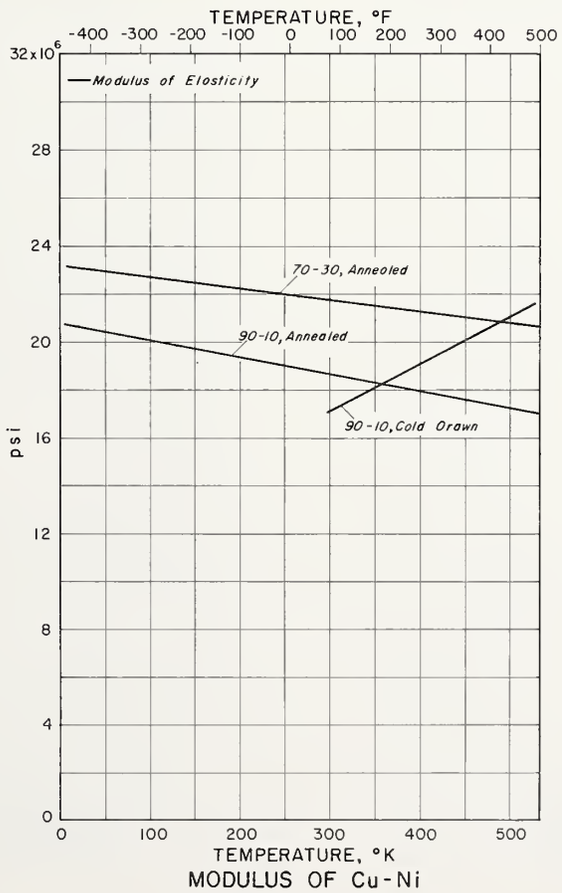
Mechanical Properties of Cu-Ni



FATIGUE BEHAVIOR OF Cu-Ni

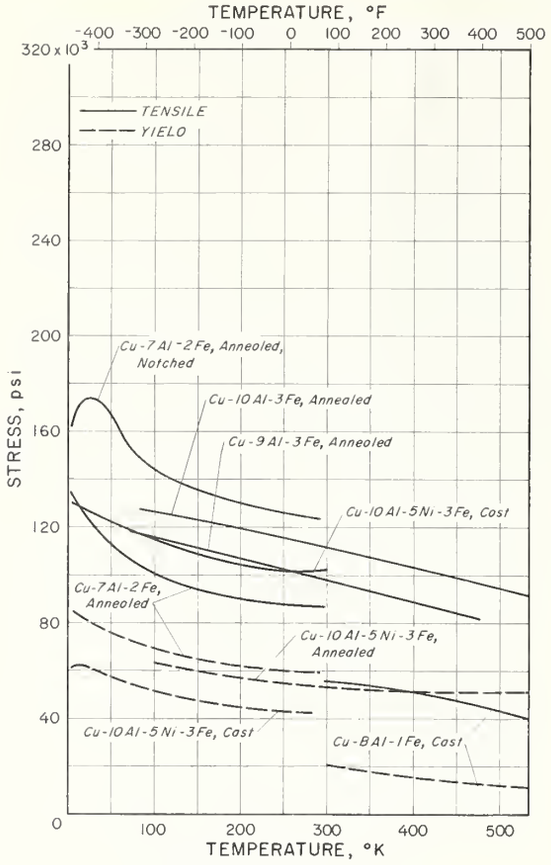


CREEP BEHAVIOR OF Cu - Ni

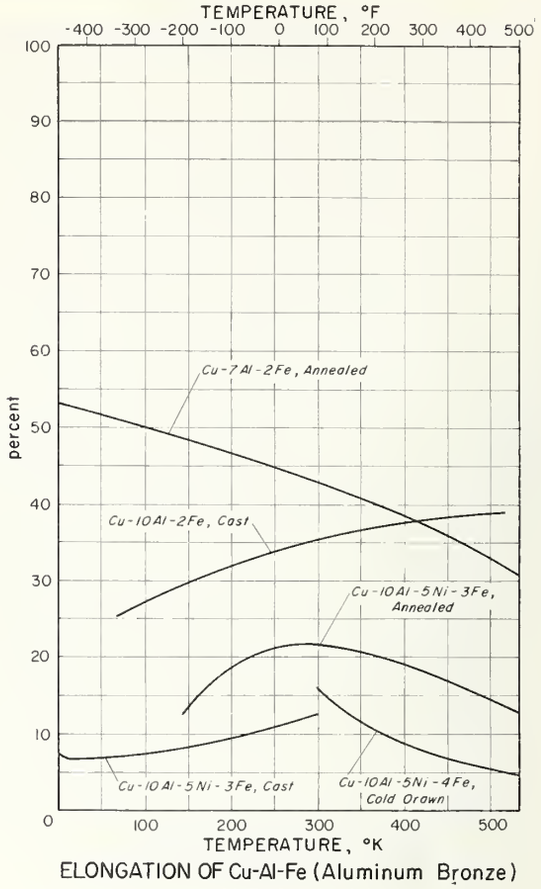


MODULUS OF Cu-Ni

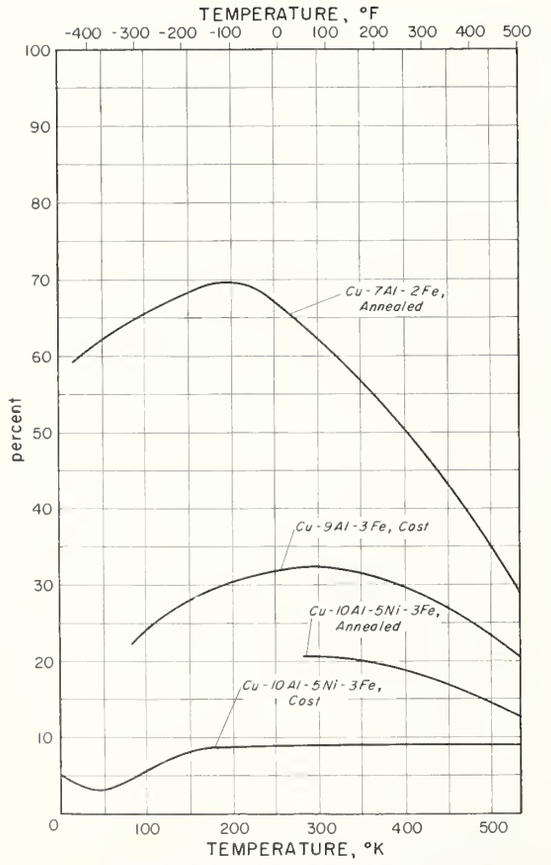
Mechanical Properties of Cu-Al-Fe (Aluminum Bronze) and Cu-Al-Fe-Ni



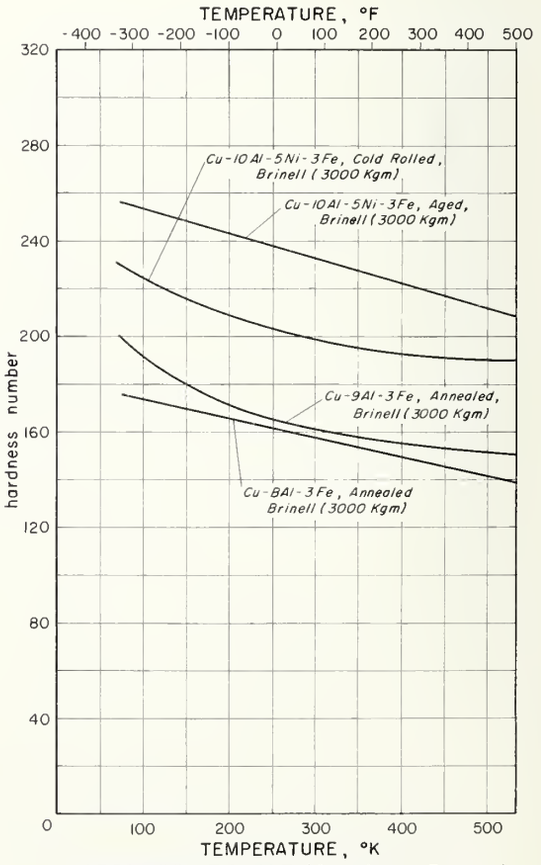
STRENGTH OF Cu-Al-Fe (Aluminum Bronze) and Cu-Al-Ni-Fe



ELONGATION OF Cu-Al-Fe (Aluminum Bronze) AND Cu-Al-Ni-Fe

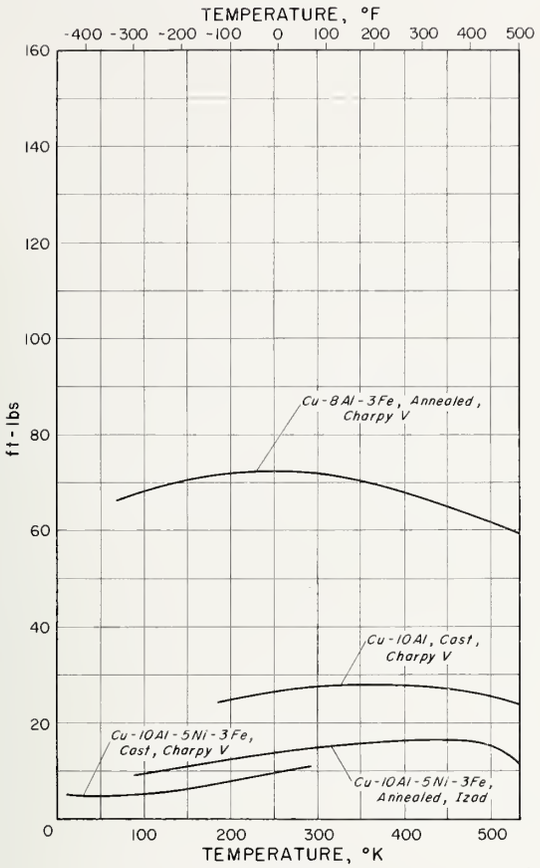


REDUCTION OF AREA OF Cu-Al-Fe (Aluminum Bronze) AND Cu-Al-Ni-Fe

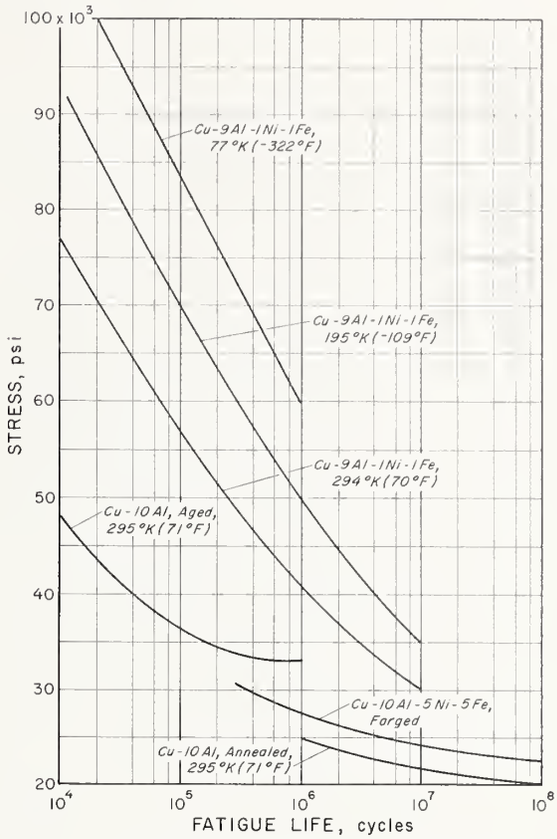


HARDNESS OF Cu-Al-Fe (Aluminum Bronze) AND Cu-Al-Ni-Fe

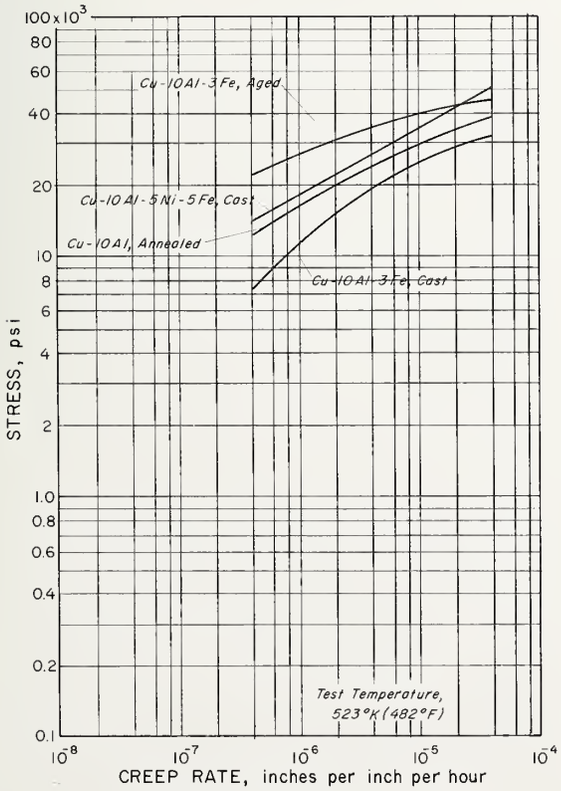
Mechanical Properties of Cu-Al-Fe (Aluminum Bronze) and Cu-Al-Fe-Ni



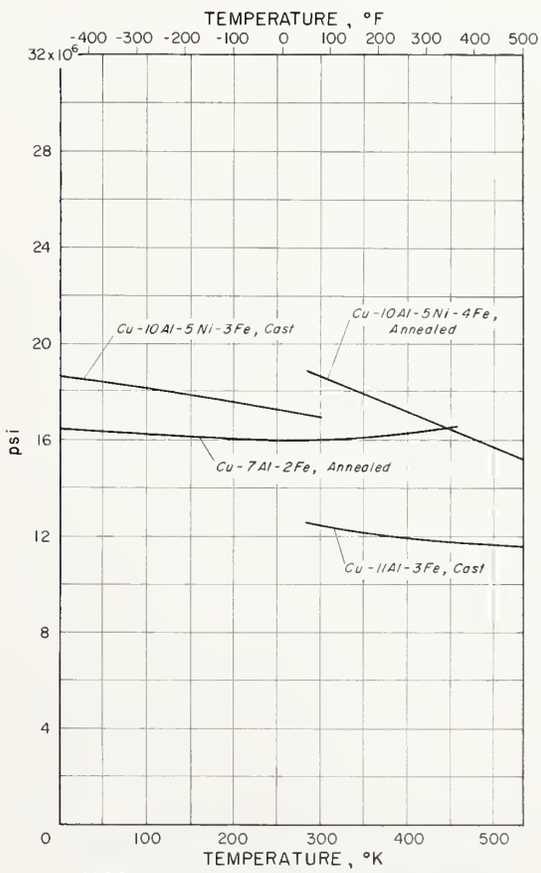
IMPACT ENERGY OF Cu-Al-Fe (Aluminum Bronze) AND Cu-Al-Ni-Fe



FATIGUE BEHAVIOR OF Cu-Al-Fe (Aluminum Bronze) and Cu-Al-Ni-Fe



CREEP BEHAVIOR OF Cu-Al-Fe (Aluminum Bronze) and Cu-Al-Ni-Fe



MODULUS OF Cu-Al-Fe (Aluminum Bronze) AND Cu-Al-Ni-Fe

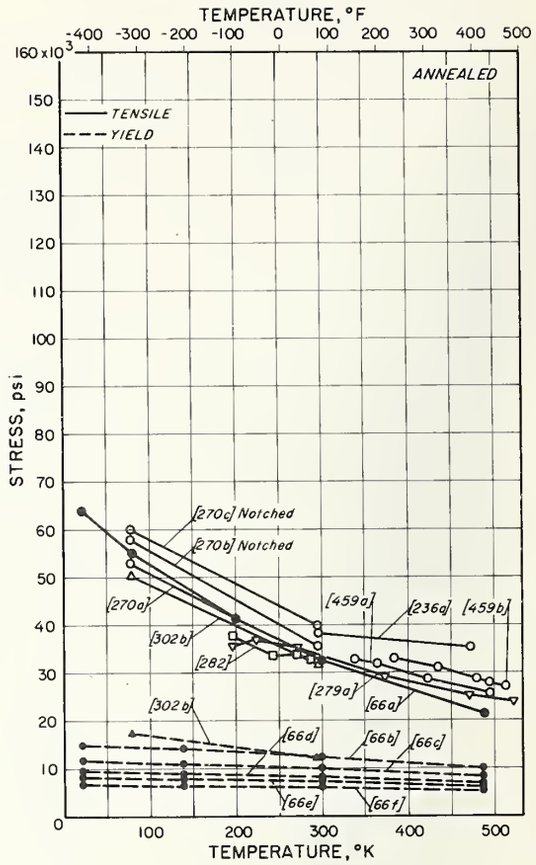
Section II

Mechanical property data from all investigations for copper and its alloys.

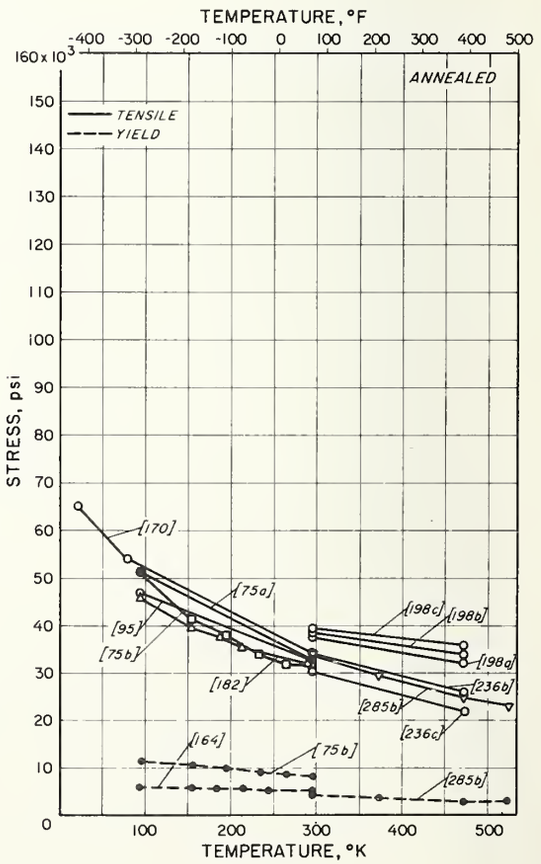
Contents

Tensile and Yield Strength of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
66a	Annealed. Wire sample - 0.030 inch diam., all samples from same wire, curve is average of values for annealing temperatures 482° to 1742°F.	99.999						66
66b	Annealed 482°F - 1 hr. in air - 0.012mm. G. S. Wire sample - 0.030 inch diam., all samples from same wire. Y.S.-0.5% strain.	99.999						66
66c	Annealed 662°F - 1 hr., H_2 atmos. - 0.015mm. G. S. Other specifications same as 66b.	99.999						66
66d	Annealed 1022°F - 1 hr., H_2 atmos. - 0.030mm. G. S. Other specifications same as 66b.	99.999						66
66e	Annealed 1382°F - 1 hr., H_2 atmos. - 0.045mm. G.S. Other specifications same as 66b.	99.999						66
66f	Annealed 1742°F - 1 hr., H_2 atmos. - 0.090mm. grain size. Other specifications same as 66b.	99.999						66
236a	Annealed 932°F - 5 hrs. Bar sample - 0.2 inch diam., strain rate = 1000 inches/inch/sec.							236
270a	Annealed 900°F - 1 hr. - air cooled. Bar sample - 0.212 inch diam., crosshead rate = 0.05 inch/minute, <0.001 inch between sample axis and loading axis.							270
270b	Bar sample - notched: 0.212 inch diam. at notch, 60° notch angle - <0.001 inch notch radius ($K_T \approx 10.3$) - 0.233 inch outer diam. Other specifications same as 270a.							270
270c	0.286 inch outer diam. Other specifications same as 270b.							270
279a	Soft.							279
282	Annealed 1472°F - 1/2 hr. - bar supplied - 5/8 inch diam. Bar sample - 0.394 inch diam.	99.75						282
302b	Annealed.	99.9						302
459a	Annealed 1157°F - 2-2/3 hr. - pickled. Wire sample - 0.114 inch diam., constant load applied while wire was heated at 5.4°F per minute until sample broke.	99.96					0.040	459
459b	Heated at 36°F per minute. Other specifications same as 459a.	99.96					0.040	459

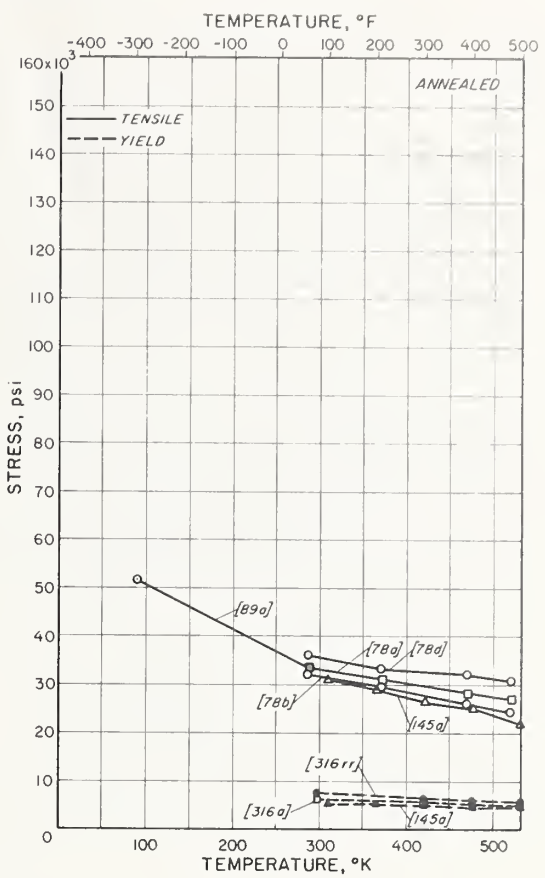


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
75a	Annealed. Bar sample - 0.504 inch diam.	99.98						75
75b	Annealed. Bar sample - 0.25 inch diam., Y.S. - 0.1% offset.	99.98						75
95	Annealed 932°F. Strip sample - about 0.039 inch × about 0.1 inch cross-sectional area, fracture strength recorded.							95
164	Annealed 932°F - 2 hrs. - 0.017mm. G.S. Bar sample - 0.158 inch diam., strain rate = 0.00017 inches/inch/sec.	99.98						164
170	Annealed - bar supplied - about 0.35 inch diam. Bar sample - 0.118 inch diam.	99.9						170
182	Annealed 1472°F - water quenched. Sheet sample - reduced section 0.788 × 0.197 × 0.0945 inch.							182
198a	Annealed 932°F - 5 hrs. - furnace cooled 12 hrs. to room temp., bar supplied - 3/8 inch diam. Bar sample - 1-1/8 inch long × 0.2 inch diam. reduced section, strain rate = 8100 inches/inch/minute.							198
198b	Strain rate = 27,000 inches/inch/minute. Other specifications same as 198a.							198
198c	Strain rate = 54,000 inches/inch/minute. Other specifications same as 198a.							198
236b	Annealed 932°F - 5 hrs. Bar sample - 0.2 inch diam., strain rate = 1 inch/inch/sec.							236
236c	Annealed 932°F - 5 hrs. Bar sample - 0.2 inch diam., strain rate = 0.001 inch/inch/sec.							236
285b	Annealed 1202°F - 1/2 hr. Bar sample - 0.197 inch diam. Y.S. - 0.01% strain.							285

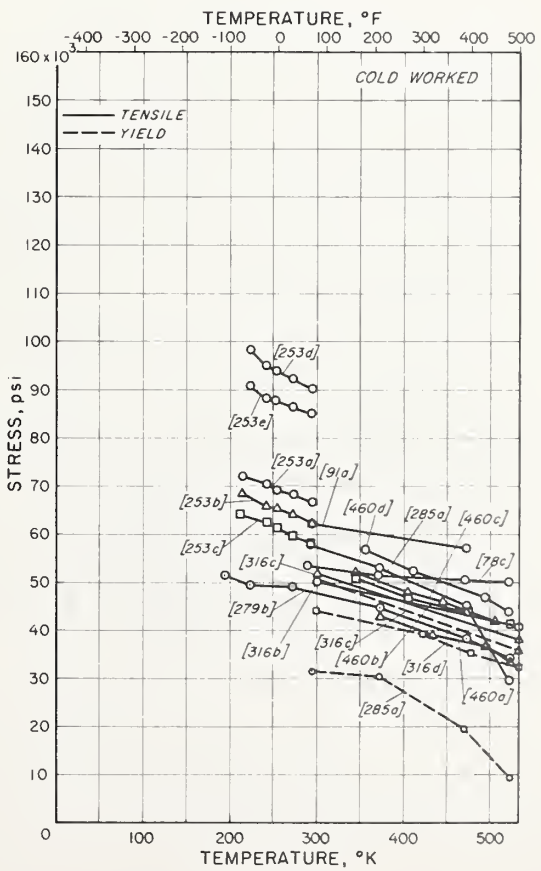


Tensile and Yield Strength of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
78a	Annealed 1382°F - after hot rolling, plate supplied. Bar sample - reduced section 2-1/2 inches long X 0.418 inch diam., crosshead rate = 0.25 inch/minute.	99.45				0.03	0.4As, 0.06P	78
78b	Annealed 1382°F - after hot rolling, plate supplied. Bar sample - reduced section 2-1/2 inches long X 0.418 inch diam., cross head rate = 0.25 inch/minute.	99.51					0.38As, 0.05O, 0.03Ni	78
78d	Soft, plate supplied. Bar sample - reduced section 2-1/2 inches long X 0.418 inch diam. Crosshead rate = 0.25 inch/minute.	98.60				0.78	0.45Si, 0.05Fe, 0.05P, 0.02As	78
89a	Annealed to "dull red" - air cooled. Bar sample - 0.118 inch diam.	99.4		0.5			0.1Pb	89
145a	Annealed 1112°F - 2 hrs. Bar sample - 0.5 inch reduced diam., fracture strength recorded, Y.S. - 0.3% offset.	99.75					0.23As	145
316a	Annealed - 0.045mm. G.S., bar supplied - 0.125 inch diam., Y.S. - 0.5% strain.	99.60	0.01				0.32As, 0.02P 0.02Fe	316
316rr	Annealed - 0.025mm. G.S., bar supplied - 0.125 inch diam. Y.S. - 0.2% offset.	99.53					0.46Te, 0.01P	316

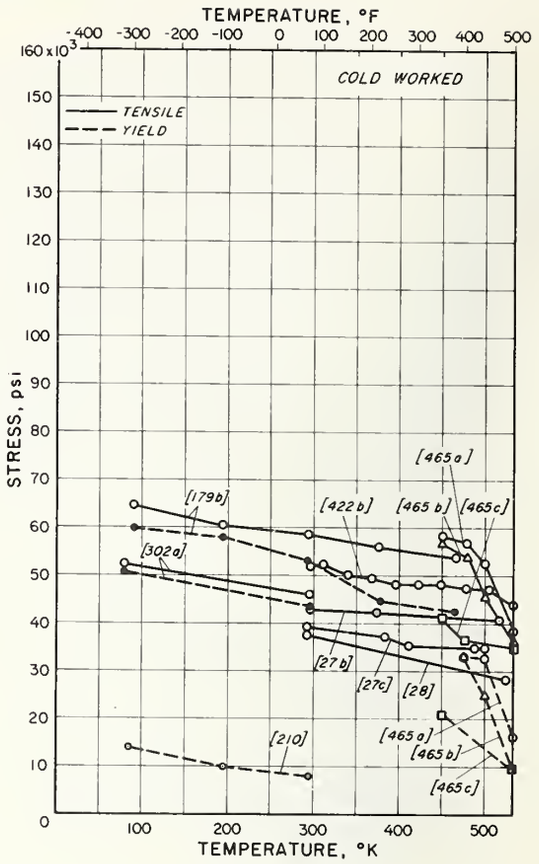


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
78c	Cold rolled to hard temper, plate supplied. Bar sample - reduced section 2-1/2 inches long X 0.418 inch diam., crosshead speed = 0.25 inch/minute.	98.60				0.78	0.45Si, 0.05Fe, 0.05P, 0.02As	78
91a	Hard.	99.09		0.91				91
253a	Drawn 88.9% from hot rolled bar, bar supplied - 1/4 inch diam. Wire sample - 0.083 inch diam.							253
253b	Drawn 80.7% from hot rolled bar, bar supplied - 1/4 inch diam. Wire sample - 0.110 inch diam.							253
253c	Drawn 67.9% from hot rolled bar, bar supplied - 1/4 inch diam. Bar sample - 0.142 inch diam.							253
253d	Drawn 95.6%, bar supplied - 0.4 inch diam. Wire sample - 0.083 inch diam.	99.5					0.5Mg	253
253e	Drawn 92.2%, bar supplied - 0.4 inch diam. Wire sample - 0.110 inch diam.	99.5					0.5Mg	253
279b	Worked.							279
285a	Hard drawn. Bar sample - 0.197 inch diam. Y.S. - 0.01% strain.							285
316b	Cold drawn 21% - R_B = 45, bar supplied - 3/4 inch diam.						0.21Te	316
316c	Cold drawn - R_B = 56, bar supplied - 3/4 inch diam., Y.S. - 0.2% offset.	99.64					0.35Te	316
316d	Drawn 37%, bar supplied - 0.125 inch diam. Y.S. - 0.2% offset.	99.53					0.46Te, 0.01P	316
460a	Cold drawn 24.9%, wire supplied - 0.114 inch diam. Wire sample - 0.099 inch diam., constant load applied while wire was heated at 36°F per minute until sample broke.	99.72					0.18O, 0.10Pb	460
460b	Cold drawn 42.4%. Wire sample - 0.086 inch diam. Other specifications same as 460a.	99.72					0.18O, 0.10Pb	460
460c	Cold drawn 50.8%. Wire sample - 0.080 inch diam. Other specifications same as 460a.	99.72					0.18O, 0.10Pb	460
460d	Cold drawn 74.8%. Wire sample - 0.057 inch diam. Other specifications same as 460a.	99.72					0.18O, 0.10Pb	460

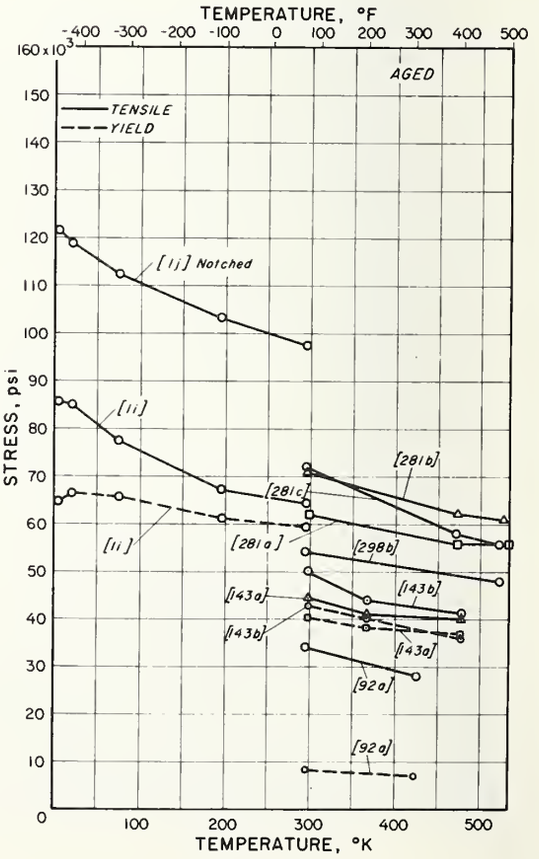


Tensile and Yield Strength of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
27b	As rolled, electrolytic tough pitch, bar supplied - 1/2 inch diam. Bar sample - reduced section - 2-1/2 inches long X 1/4 inch diam., stress rate constant: 1120 psi/minute, tested in carbon dioxide.	99.92					0.08O	27
27c	As rolled, bar supplied - 1/2 inch diam. Bar sample - reduced section - 2-1/2 inches long X 1/4 inch diam., stress rate constant: 1120 psi/minute, tested in both air and hydrogen, but differences in test results negligible.	99.54					0.13As, 0.13O, 0.10Pb, 0.08Sn, 0.02Fe	27
28	Rolled, bar supplied - 1/2 inch diam. Bar sample - reduced section - 2-1/2 inches long X 1/4 inch diam.	99.84					0.08O, 0.01S	28
179b	Cold worked, electrolytic tough pitch. Bar sample - 0.177 inch diam.							179
210	Cold rolled, oxygen-free high-conductivity, bar supplied, 0.875 inch diam.	99.97						210
302a	Cold rolled. Y.S.	99.9						302
422b	Rolled. Bar sample - 0.72 inch diam.							422
465a	Hard (original condition). Wire sample - 0.197 inch diam., sample strained to hard condition - then tested after 1/4 hr., Y.S. - 0.2% offset.							465
465b	Tested after 1 hr. Other specifications same as 465a.							465
465c	Tested after 256 hrs. Other specifications same as 465a.							465

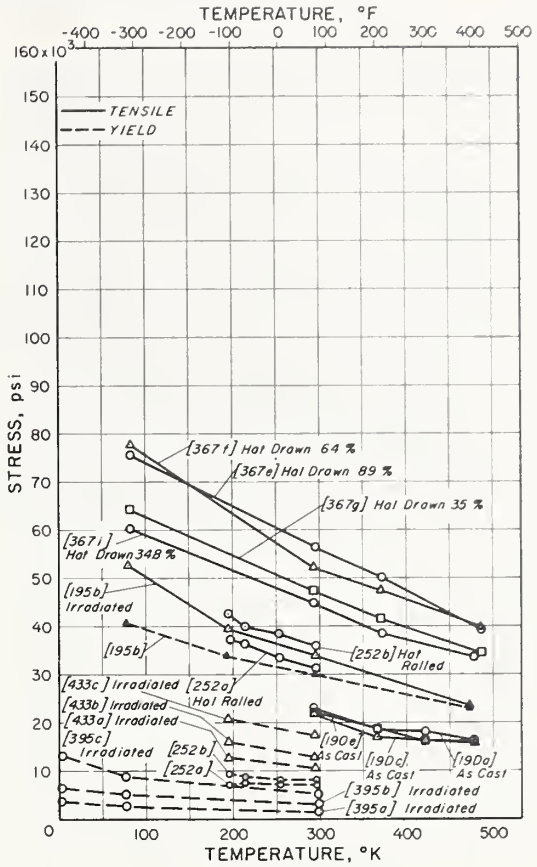


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1i	Aged 450°C - 1 hr. - 0.203mm. G.S. - R_B = 68 - after first heating to 950°C - water quenching - then cold drawing 85-90%, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute.	Bal	With the exception of Zr, these elements are approximate.				0.18Zr, 16ppm Ag, 12ppm S, 2ppm As, 5ppm Sb, < 3ppm O	1
1j	Notched sample - 0.250 inch diam. at roots of circumferential notch - 0.005 ± 0.0005 inch notch radius (K_T = 5.0). Other specifications same as 1i.		Composition same as 1i					1
92a	Heated 1562°F - 1/2 hr. - water quenched. Y.S. - 0.2% strain.	99.77					0.23Zr	92
143a	Aged 750 to 800°F - 1 to 2 hrs., - R_B = 48 - after cold drawing 75%, bar supplied - 3 inch diam. Bar sample - reduced section - 2.25 inches long X 0.48 inch diam., Y.S. - 0.2% offset.	99.84					0.16Zr	143
143b	R_B = 57. Other specifications same as 143a.	99.82					0.18Zr	143
281a	Aged at 752°F - after cold drawing 54%. Bar sample - 0.25 inch diam., crosshead speed = 0.02 inch/minute.	99.85					0.15Zr	281
281b	Aged at 707°F - after cold drawing 84%. Bar sample - 0.25 inch diam., crosshead speed = 0.02 inch/minute.	99.85					0.15Zr	281
281c	Aged 842°F - after cold drawing 84%. Bar sample - 0.25 inch diam., crosshead speed = 0.02 inch/minute.	99.3					0.7Cr	281
298b	Aged ("fully heat treated"), bar supplied - 3/4 inch diam., crosshead speed = 0.1 inch/minute.	99.4					0.6Cr	298

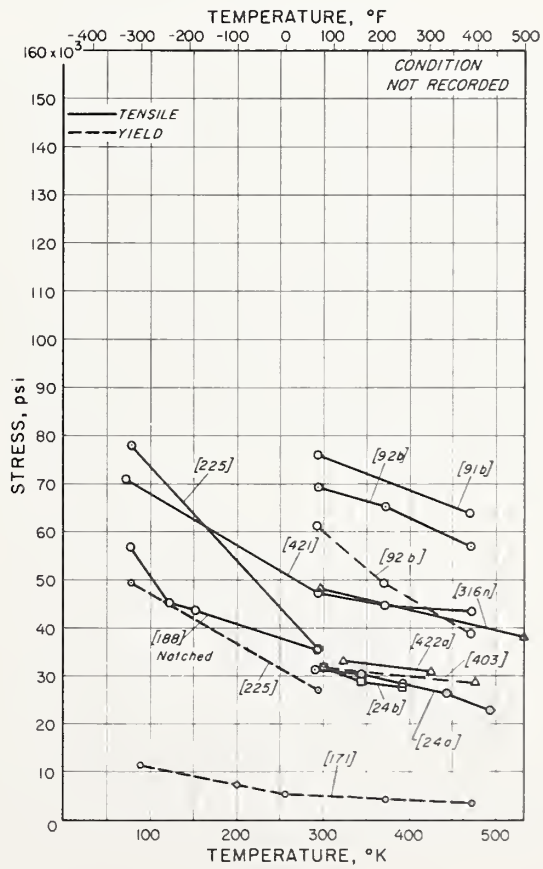


Tensile and Yield Strength of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
190a	As cast, electrolytic tough pitch. Bar sample, 2 tests/temp.							190
190c	As cast, oxygen-free high-conductivity. Bar sample, 2 tests/temp.							190
190e	As cast, phosphorized, bar supplied. 2 tests/temp.							190
195b	Irradiated approx. 212°F - 6 months - in flux of 6×10^{12} slow neutrons/cm^2/sec. - total dose was 5.1×10^{19} slow neutrons/cm^2 - after annealing at 842°F - 1 hr., oxygen-free high-conductivity, wire supplied - 0.080 inch diam. Wire sample - 6 inches long × 0.048 inch diam., strain rate = 0.000082 inch/inch/sec., Y.S. - 0.2% offset.	99.99						195
252a	Hot rolled, electrolytic tough pitch, bar supplied - 1.58 inches square. Y.S. - 0.2% offset.	99.96 99.98						252
252b	Hot rolled, bar supplied - 1.58 inches square. Y.S. - 0.2% offset.	99.5					0.5Mg	252
367e	Drawn at 302°F - 88.7%, electrolytic tough pitch, bar supplied - 0.25 inch diam. Wire sample - 0.025 inch diam., 212°F tests made in boiling water - 419°F tests made in hot Crisco, 3 tests at -310°F - 2 tests other temps.							367
367f	Drawn 64.5% at 302°F - 3 tests each at room temp. and 212°F. Other specifications same as 367e.							367
367g	Drawn 34.8% at 302°F - 5 tests at -310°F. Other specifications same as 367e.							367
367i	Drawn 34.8% at 392°F - 3 tests each at -310 and 212°F. Other specifications same as 367e.							367
395a	Irradiated with 10^{17} neutrons/cm^2.							395
395b	Irradiated with 10^{18} neutrons/cm^2.							395
395c	Irradiated with 10^{19} neutrons/cm^2.							395
433a	Irradiated with 3×10^{11} fast neutrons/cm^2/sec. for 3 weeks - after first annealing approx. 400°C to 0.4mm. G.S. - then swaging 50%, wire supplied - 0.085 inch diam. Wire sample - 0.060 inch diam., lower yield strength plotted.	99.999						433
433b	0.076mm. G.S. Other specifications same as 433a.							433
433c	0.013mm. G.S. Other specifications same as 433a.							433

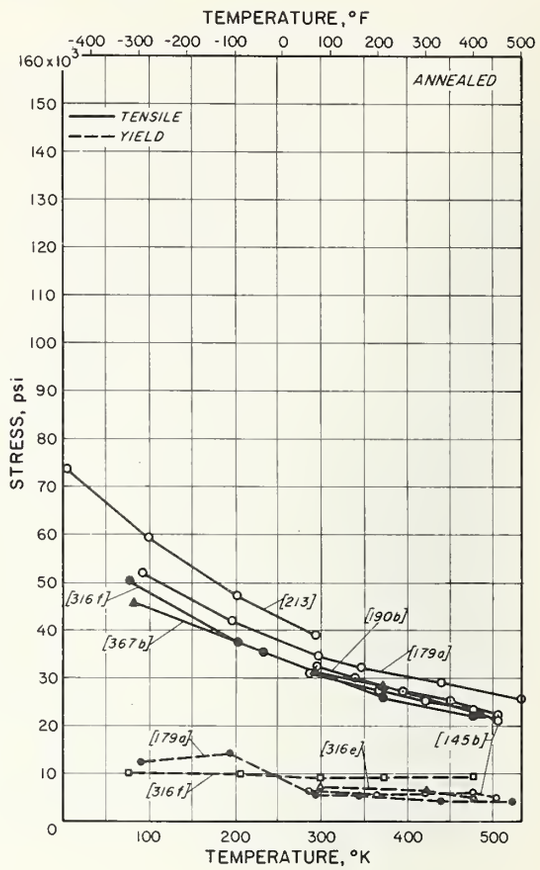


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
24a	Electrolytic tough pitch	99.9						24
24b	Lake copper	99.9						24
91b		99.71					0.29 Cr	91
92b		99.32					0.68Cr	92
171	Greater than 0.024mm G.S., Y.S. - 0.2% offset.	99.47	0.53					171
188	Plate sample - notched (Tipper) - 0.76 × 0.61 inch at notch - approx. 0.01 inch notch radius - 45° ($K_T \approx 6.2$).	99.50					0.37As, 0.07P, 0.04Ni	188
225	Y.S. - 0.1% offset.	99.8						225
316n	R_B = 38, oxygen-free high-conductivity, bar supplied - 3/4 inch diam.	99.96						316
403								403
421	Bar sample.							421
422a								422

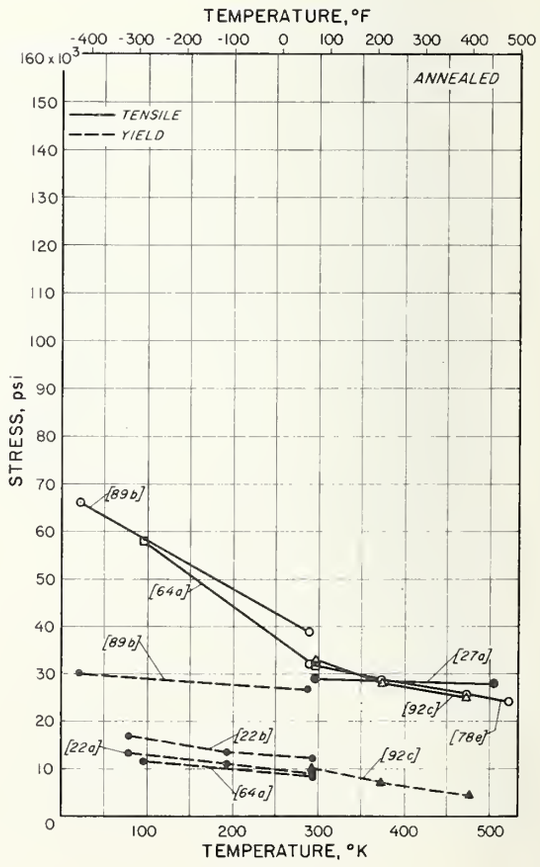


Tensile and Yield Strength of Copper (Electrolytic Tough Pitch)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
145b	Annealed 1112°F - 2 hrs. Bar sample - reduced section - 2 inches long × 0.5 inch diam., fracture strength recorded. Y.S. - 0.3% offset.							145
179a	Annealed 1292°F - 1/2 hr., N_2 atmos. Bar sample - 0.177 inch diam.							179
190b	Annealed 600°F - 1/2 hr. - after rolling at 1200°F. Bar sample - 2 tests/temp. except at 150 and 350°F.							190
213	Annealed 1112°F - several hrs., Ar atmos. Wire sample - 0.02 inch reduced diam.						0.03O	213
316e	Annealed - 0.025mm. G.S. Bar sample - 0.125 inch diam., Y.S. - 0.2% offset.	99.96						316
316f	Annealed 1150°F - 1/2 hr. - 0.040mm. G.S. - after hot rolling. Sheet sample - 1/2 inch wide × 1/8 inch thick, tested parallel to rolling direction, Y.S. - 0.2% offset.	99.90						316
367b	Annealed 1382°F - 5 minutes - after cold drawing 96%, bar supplied - 0.25 inch. Wire sample - 0.025 inch diam., 212°F tests made in boiling water - 419°F tests made in hot Crisco, 3 tests at 212°F - 2 tests at each of other temps.							367

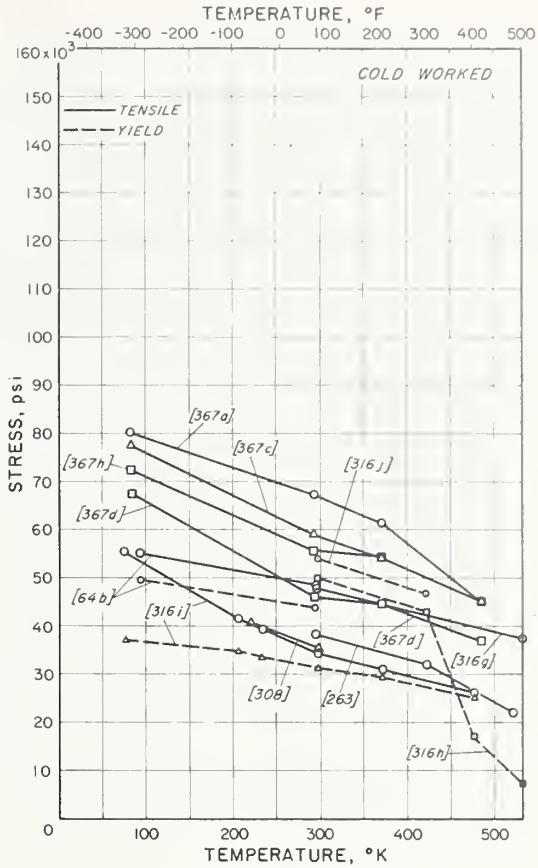


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
22a	Annealed 932°F - air cooled. Bar sample - 0.138 inch diam. strain rate ≈ 0.001 inch/inch/sec., Y.S. - 0.5% offset.	99.9						22
22b	Strain rate ≈ 100 inches/inch/sec. Other specifications same as 22a.	99.9						22
27a	Annealed 1382°F, CO_2 atmos. - 2 hrs., bar supplied - 1/2 inch diam. Bar sample - reduced section 2-1/2 inches long × 1/4 inch diam., stress rate constant: 1120 psi/minute, tested in carbon dioxide.	99.92					0.08O	27
64a	Annealed.							64
78e	Annealed 1382°F - after hot rolling, plate supplied. Bar sample - reduced section 2-1/2 inches long × 0.418 inch diam., crosshead speed = 0.25 inch/minute.	99.91				0.03	0.04O, 0.01As	78
89b	Annealed 1382°F - water quenched. Bar sample - 0.118 inch diam.							89
92c	Soft. Y.S. - 0.2% strain.							92



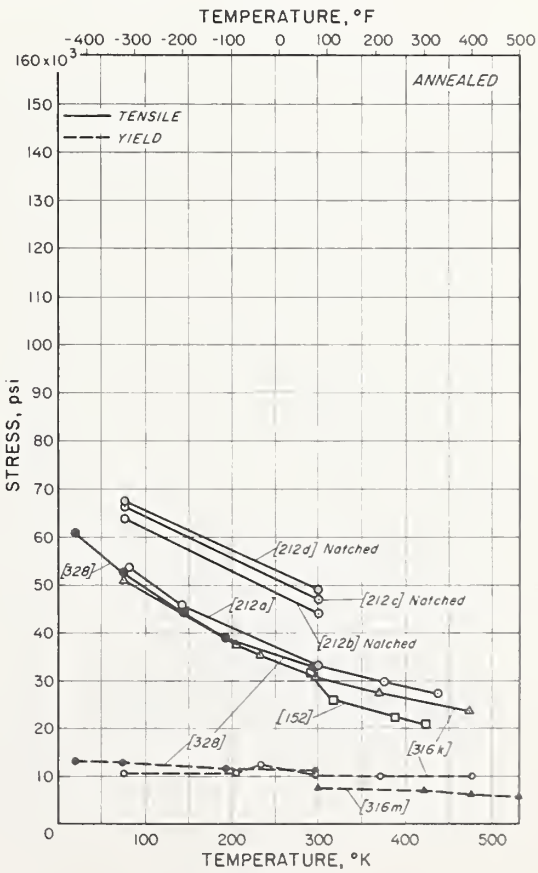
Tensile and Yield Strength of Copper (Electrolytic Tough Pitch)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
64b	Drawn 50%.							64
263	Cold drawn 25%. Bar sample - 0.505 inch diam., cross-head speed = 1/4 inch/minute.	99.97						263
308	Drawn.	99.9					0.030	308
316g	Cold drawn 21%, bar supplied - 3/4 inch diam. Bar sample - 0.505 inch diam.	99.90						316
316h	Drawn 84%. Bar sample - 0.125 inch diam., Y.S. - 0.5% strain.	99.96						316
316i	Cold rolled 5-7% - 0.042mm. G.S. - after hot rolling and annealing 1150°F - 1/2 hr. Sheet sample - 1/2 inch wide X 1/8 inch thick, tested parallel to rolling direction, Y.S. - 0.2% offset.	99.90						316
316j	Drawn 84%. Bar sample - 0.125 inch diam., Y.S. - 0.2% offset.	99.95	0.01				0.03Ag	316
367a	Cold drawn 96%, bar supplied - 0.25 inch. Wire sample - 0.025 inch diam., 212°F tests made in boiling water - 419°F tests made in hot Crisco, 2 tests/temp., breaking strength recorded.							367
367c	Cold drawn 64.5%. Other specifications same as 367a.							367
367d	Cold drawn 34.8%. Other specifications same as 367a.							367
367h	Heated 302°F - 10 minutes - in oil - after cold drawing 96%, bar supplied - 0.25 inch diam. Wire sample - 0.025 inch diam., 212°F tests made in boiling water - 419°F tests made in hot Crisco, 2 tests/temp. except at 212°F: 4.							367



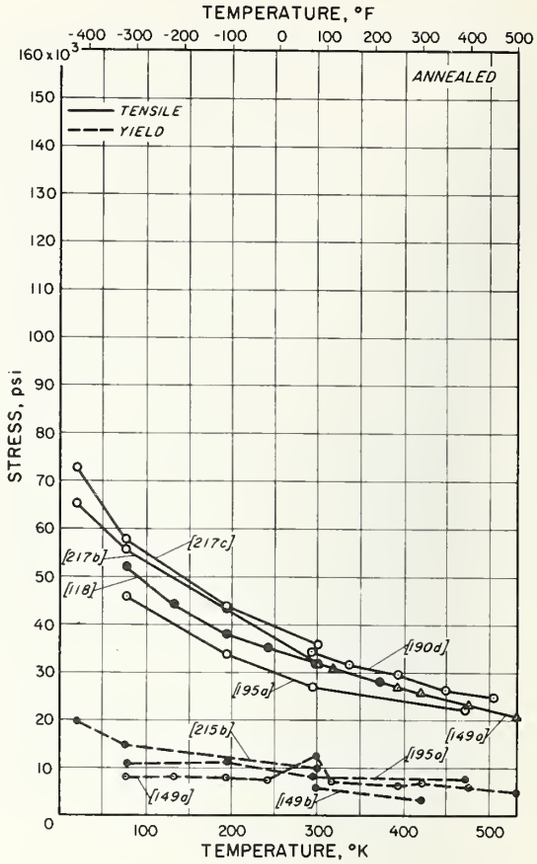
Tensile and Yield Strength of Copper (Oxygen-Free High-Conductivity)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
152	Annealed - 0.025mm. G.S. - R_F = 34.0. Bar sample - 0.505 inch diam., rate of loading = 3200 psi/hr. (3200 psi applied at 1 hr. intervals).	99.99						152
212a	Annealed 800°F - 5 hrs. - after cold rolled 75%, bar supplied = 0.875 inch diam. Bar sample.	99.97						212
212b	Circumferential V-notch, 120°, minimum to maximum cross-sectional area = 11 to 15%, 0.010 inch notch radius. Other specifications same as 212a.	99.97						212
212c	90° notch. Other specifications same as 212b.	99.97						212
212d	60° notch. Other specifications same as 212b.	99.97						212
316k	Annealed 1150°F - 1/2 hr. - 0.045mm. G.S. - after hot rolling. Sheet sample - 1/2 inch wide X 1/8 inch thick, tested parallel to rolling direction.	99.96						316
316m	Annealed - 0.025mm. G.S., bar supplied - 0.125 inch diam. Y.S. - 0.5% strain.	99.98	0.01					316
328	Annealed (soft) - ASTM G.S. # = 5, R_H = 86, bar supplied - 3/4 inch diam. Bar sample - 0.177 inch diam. at ends of 1-1/4 inch long reduced section tapered to 0.174 inch diam. at center, 5 tests/temp. at 3 temps. - 6 tests at -323°F, crosshead speed either 0.2 or 0.02 inch/minute at all temperatures, values to nearest 100 psi, Y.S. - 0.2% offset.	Copper + Silver = 99.99						328

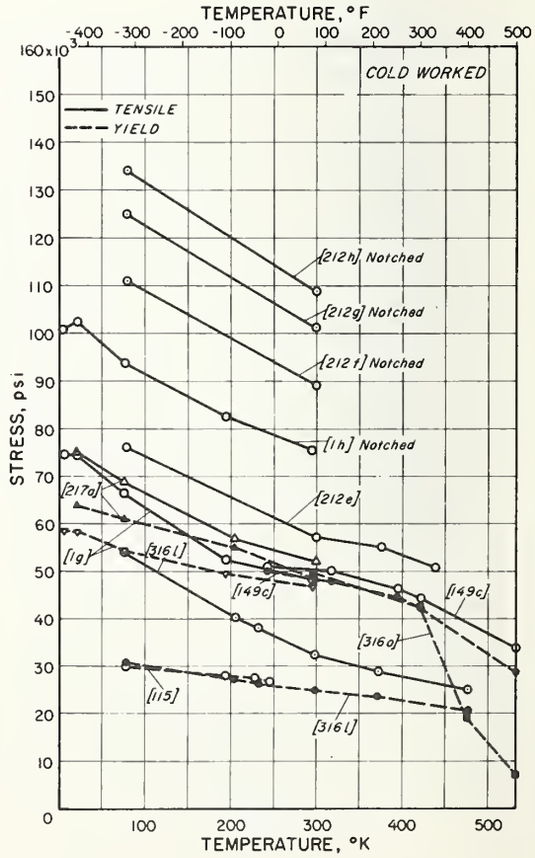


Tensile and Yield Strength of Copper (Oxygen-Free High-Conductivity)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
118	Annealed 800°F - 1 hr. - 0.025mm. G.S. - R_F = 34. Bar sample - 0.505 inch reduced diam. - polished, rate of loading beyond initial yielding = 1% reduction of area per minute.	99.99						118
149a	Annealed - 0.025mm. G.S. Bar sample - 0.505 inch diam. - 2 inch reduced section, strain rate ≈0.01 inch/inch/minute, Y.S. - 0.2% offset.	99.99						149
149b	Annealed - 0.12mm. G.S. Other specifications same as 149a.	99.99						149
190d	Annealed 600°F - 1/2 hr. - after rolling at 1200°F. Bar sample, 2 tests/temp. except at 150 and 350°F.							190
195a	Annealed 842°F - 0.010 to 0.015mm. G.S. - 1 hr. - after drawing 64%, wire supplied - 0.080 inch diam. Wire sample - 0.048 inch diam. × 6 inches long, strain rate ≈ 0.000082 inch/inch/sec., Y.S. - 0.2% offset.	99.99						195
217b	Annealed 392°F - 8 hrs., He atmos. - 0.014mm. G.S. - as received, annealed. Foil sample - 0.010 inch thick × 1/2 inch wide, long axis parallel to rolling direction, strain rate ≈0.0005 inch/inch/minute to yield and ≈0.02 inch/inch/minute beyond, 4 tests at 80° and -423°F - 5 tests at -323°F. Y.S. - 0.1% offset.							217
217c	Annealed - 0.011mm. G.S. - R_F = 49. Wire sample - square - 0.080 inch, strain rate ≈0.0005 inch/inch/minute to yield and ≈0.02 inch/inch/minute beyond, 4 to 8 tests/temp.							217

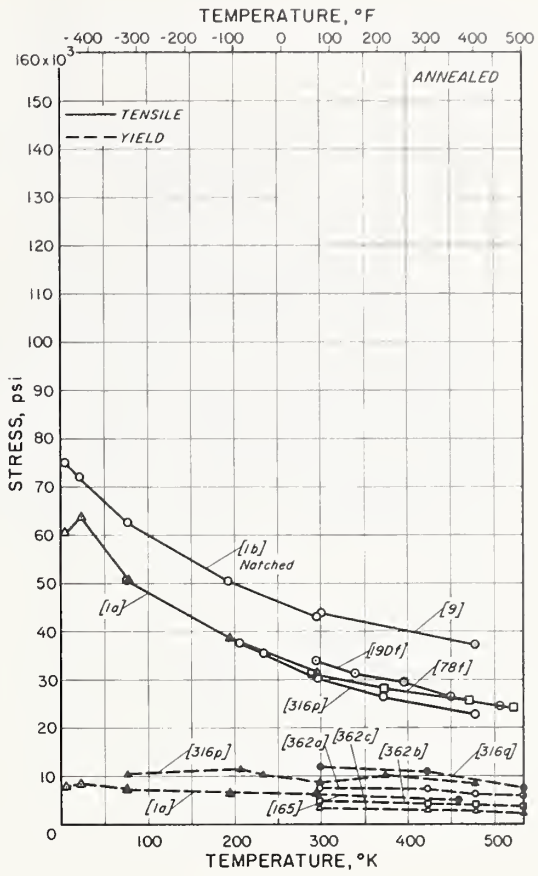


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
1g	Cold drawn 60% - 0.287 to 2.00mm. G.S. - R_B = 45 to 53, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long × 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute. Y.S. = 0.2% offset.	Bal		1ppm		4ppm	16ppm Ag, 12ppm S, 2ppm As, 5ppm Sb, < 3ppm O	1
1h	Notched sample - 0.250 inch diam. at roots of circumferential notch, 0.005 ± 0.0005 inch notch radius (K_T = 5.0). Other specifications same as 1g.	Bal		1ppm		4ppm	16ppm Ag, 12ppm S, 2ppm As, 5ppm Sb, < 3ppm O	1
115	Cold drawn 11.5% - after annealing in vacuum - 977°F - 6 hrs. - furnace cooled - 0.11mm. G.S. for anneal. Bar sample - 0.505 inch diam., tested at constant crosshead speed, Y.S. - 0.2% offset.							115
149c	Drawn 40%. Bar sample - 0.507 inch diam. - 2 inch reduced section, strain rate ≈0.01 inch/inch/minute, Y.S. - 0.2% offset.	99.99						149
212e	Cold rolled 75%, bar supplied - 0.875 inch diam. Bar sample.	99.97						212
212f	Circumferential V-notch - 120° - minimum to maximum cross-sectional area = 11 to 15% - 0.010 inch notch radius. Other specifications same as 212e.	99.97						212
212g	90° notch. Other specifications same as 212f.	99.97						212
212h	60° notch. Other specifications same as 212f.	99.97						212
217a	Drawn - R_B = 57. Bar sample - 1/4 inch diam., strain rate ≈0.0005 inch/inch/minute to yield and ≈0.02 inch/inch/minute beyond, 2 tests/temp., Y.S. - 0.2% offset.							217
316ℓ	Cold rolled 5 to 7% - 0.040mm. G.S. - after not rolling and annealing 1150°F - 1/2 hr. Sheet sample - 1/2 inch wide × 1/8 inch thick, tested parallel to rolling direction, Y.S. - 0.2% offset.	99.96						316
316o	Drawn 84%, bar supplied - 0.125 inch diam. Y.S. - 0.5% strain.	99.98	0.01					316

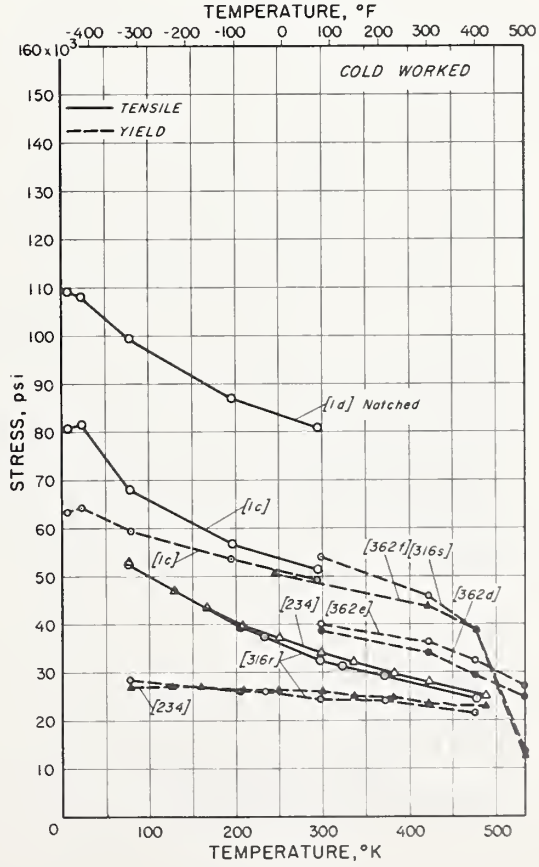


Tensile and Yield Strength of Copper (Phosphorized)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1100°F - 1 hr. - 0.036mm. G.S. - R_F = 35, bar supplied - 3/4 inch diam. Bar sample - 1.5 inch reduced section - 0.247 inch at middle - 0.250 inch at ends, crosshead speed = 0.02 inch/minute, Y.S. - 0.2% offset.	99.97					0.03P	1
1b	Notched sample - 0.25 inch diam. at roots of circumferential notch - 0.005 ± 0.0005 inch notch radius (K_T = 5.0). Other specifications same as 1a.	99.97					0.03P	1
9	Annealed - R_B = 34, bar supplied - 3/4 inch diam.	99.97					0.02P	9
78f	Annealed 1382°F - after hot rolling, plate supplied. Bar sample - reduced section 2-1/2 inches long × 0.418 inch diam., crosshead rate = 0.25 inch/minute.	99.92				0.03	0.05P, 0.01As	78
165	Annealed 1022°F - 1/2 hr. - 0.020mm. Y.S. - 0.2% offset.	99.94					0.06P	165
190f	Annealed 600°F - 1/2 hr. - after forging and rolling at 1200°F, bar supplied, 2 tests/temp. except 150 and 350°F.							190
316p	Annealed 1150°F - 1/2 hr. - after hot rolling, 0.045mm. G.S. Sheet sample - 1/8 inch thick × 1/2 inch wide, tested parallel to rolling direction, Y.S. - 0.2% offset.	99.90					0.02 - 0.04P	316
316q	Annealed - 0.013mm. G.S. Bar sample - 0.125 inch diam., Y.S. - 0.5% strain.	99.95					0.01P	316
362a	Annealed - 0.015mm. G.S., bar supplied - 3 inch diam. Bar sample - 1/8 inch diam., Y.S. - 0.2% offset.	99.98					0.02P	362
362b	Annealed - 0.032mm. G.S., bar supplied - 3 inch diam. Bar sample - 1/8 inch diam., Y.S. - 0.2% offset.	99.98					0.02P	362
362c	Annealed - 0.070mm, G.S., bar supplied - 3 inch diam. Bar sample - 1/8 inch diam., Y.S. - 0.2% offset.	99.98					0.02P	362

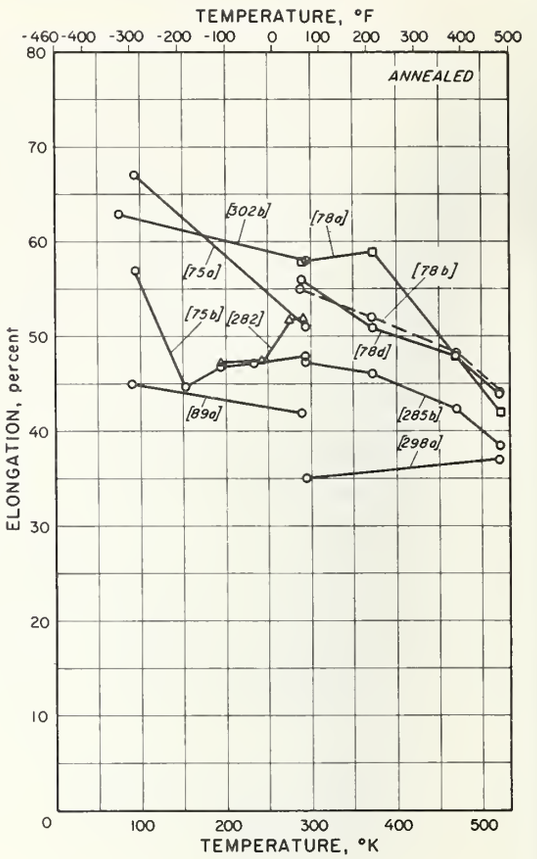


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1c	Cold drawn 26% - 0.144mm. G.S. - R_B = 50, bar supplied - 3/4 inch diam. Bar sample - 1.5 inch reduced section - 0.247 inch at middle - 0.250 inch at ends, crosshead speed = 0.02 inch/minute, Y.S. - 0.2% offset.	99.97					0.03P	1
1d	Cold drawn 26%. Notched sample - 0.25 inch diam. at roots of circumferential notch - 0.005 ± 0.0005 inch notch radius (K_T = 5.0). Other specifications same as 1c.	99.97					0.03P	1
234	Cold rolled 5 to 7%. Plate sample - 1/4 inch thick - cut parallel to rolling direction, crosshead rate = 0.119 inch/minute for U.T.S. and 0.0059 inch/minute for Y.S., 2 to 3 tests/temp, .Y.S. - 0.2% offset.							234
316r	Cold rolled 5 to 7% - 0.047mm. G.S. - after hot rolling and annealing 1150°F - 1/2 hr. Sheet sample - 1/8 inch thick × 1/2 inch wide, tested parallel to rolling direction.	99.90					0.02 - 0.04P	316
316s	Drawn 84%, bar supplied - 0.125 inch diam. Y.S. - 0.5% strain.	99.95					0.01P	316
362d	Drawn 21%, bar supplied - 3 inch diam. Bar sample - 1/8 inch diam., Y.S. - 0.2% offset.	99.98					0.02P	362
362e	Drawn 37%, bar supplied - 3 inch diam. Bar sample - 1/8 inch diam., Y.S. - 0.2% offset.	99.98					0.02P	362
362f	Drawn 84%, bar supplied - 3 inch diam. Bar sample - 1/8 inch diam., Y.S. - 0.2% offset.	99.98					0.02P	362

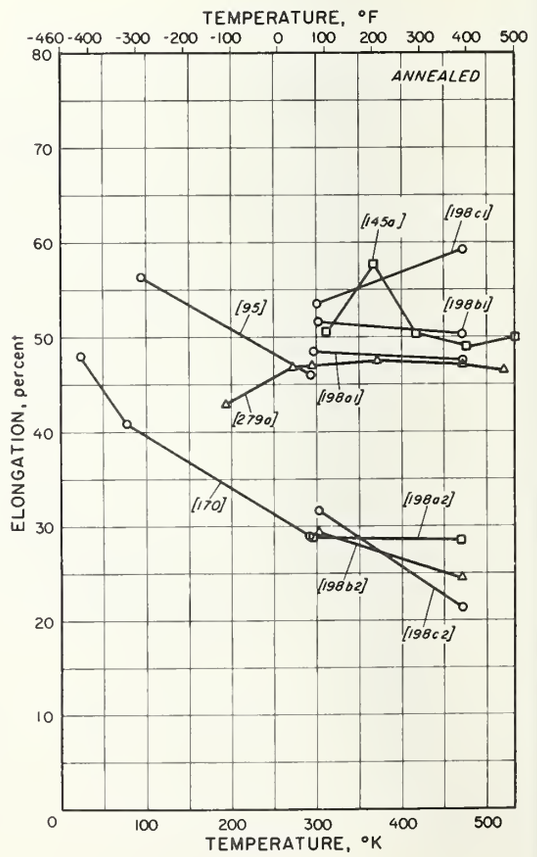


Tensile Elongation of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
75a	Annealed. Bar sample - 0.504 inch diam., 2 inch G. L.	99.98						75
75b	Annealed. Bar sample - 0.25 inch diam., 2 inch G. L.	99.98						75
78a	Annealed 1382°F - after hot rolling, plate supplied. Bar sample - reduced section 2-1/2 inches long X 0.418 inch diam., crosshead speed = 0.25 inch/minute, 2 inch G. L.	99.45				0.03	0.4As, 0.06P	78
78b	Annealed 1382°F - after hot rolling, plate supplied. Bar sample - reduced section 2-1/2 inches long X 0.418 inch diam., crosshead speed = 0.25 inch/minute, 2 inch G. L.	99.51					0.38As, 0.05O, 0.03Ni	78
78d	Soft, plate supplied. Bar sample - reduced section - 2-1/2 inches long X 0.418 inch diam., crosshead speed = 0.25 inch/minute, 2 inch G. L.	98.60				0.78	0.45Si, 0.05Fe, 0.05P, 0.02As	78
89a	Annealed to "dull red" - air cooled. Bar sample - 0.118 inch diam., 1.18 inch G. L.	99.4		0.5			0.1Pb	89
282	Annealed 1472°F - 1/2 hr., bar supplied - 5/8 inch diam. Bar sample - 0.394 inch diam., 2 inch G. L.	99.75						282
285b	Annealed 1202°F - 1/2 hr. Bar sample - 0.197 inch diam.,							285
298a	Annealed 1382°F, bar supplied - 3/4 inch diam. Crosshead speed = 0.1 inch/minute, 2 inch G. L.						0.6Cr	298
302b	Annealed. 2 inch G. L.							302

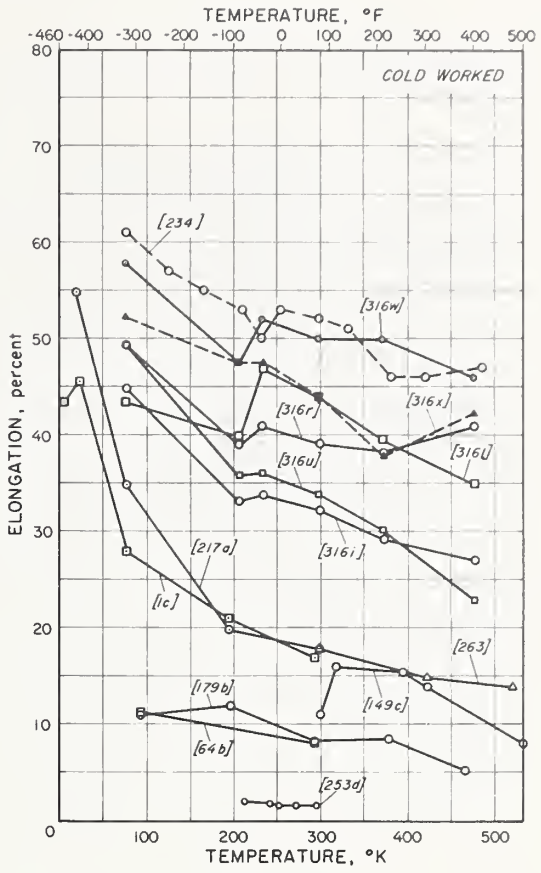


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
95	Annealed 932°F. Strip sample - approx. 0.1 inch wide X 0.039 inch thick, 0.788 inch G. L.							95
145a	Annealed 1112°F - 2 hrs. Bar sample - reduced section - 2 inches long X 0.5 inch diam., 2 inch G. L.	99.75					0.23As	145
170	Annealed, bar supplied - 0.315 to 0.394 inch diam. Bar sample - 0.118 inch diam., 1.18 inch G. L.	99.9						170
198a1	Annealed 932°F - 5 hrs. - furnace cooled 12 hrs. to room temp., bar supplied - 3/8 inch diam. Bar sample - reduced section - 1-1/8 inches long X 0.20 inch diam., strain rate = 8100 inches/inch/minute, total elongation recorded, 1.11 inch G. L.							193
198a2	Elongation to U. T. S. recorded. Other specifications same as 198a1.							198
198b1	Strain rate = 27,000 inches/inch/minute. Other specifications same as 198a1.							198
198b2	Strain rate = 27,000 inches/inch/minute. Other specifications same as 193a2.							198
198c1	Strain rate = 54,000 inches/inch/minute. Other specifications same as 198a1.							198
198c2	Strain rate = 54,000 inchzs/inch/minute. Other specifications same as 198a2.							198
279a	Soft. 2 inch G. L.							279

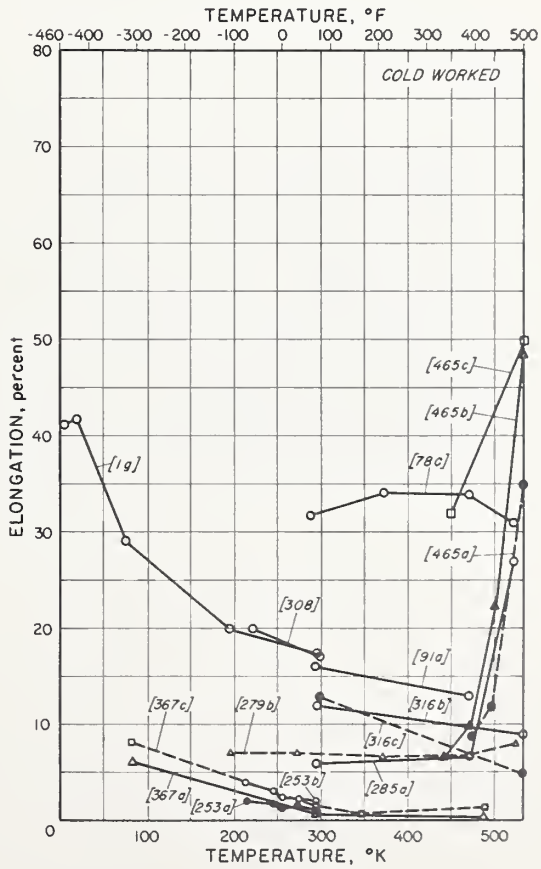


Tensile Elongation of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1c	Cold drawn 26% - 0.144mm. G.S. - R_B = 50, phosphorized, bar supplied - 3/4 inch diam. Bar sample - reduced section 1.5 inches long - 0.247 inch diam. at middle - 0.250 inch diam. at ends, crosshead speed = 0.02 inch/minute, 1 inch G.L.	99.97					0.03P	1
64b	Drawn 50%, electrolytic tough pitch.							64
149c	Drawn 40%, oxygen-free high-conductivity. Bar sample - reduced section - 2 inches long X 0.505 inch diam., strain rate ≈0.01 inch/inch/minute.							149
179b	Cold worked, electrolytic tough pitch. Bar sample - 0.177 inch diam., 1.97 inch G.L.							179
217a	Drawn - R_B = 57, oxygen-free high-conductivity. Bar sample - 1/4 inch diam., strain rate ≈0.0005 inch/inch/minute to yield and ≈0.02 inch/inch/minute beyond, 2 tests/temp., 1 inch G.L.							217
234	Cold rolled 5 to 7%, phosphorized. Plate sample - 1/4 inch thick - cut parallel to rolling direction, crosshead speed = 0.0059 inch/minute to Y.S. and 0.119 inch/minute to U.T.S., 2 to 3 tests/temp., 2 inch G.L.							234
253d	Drawn 95.6%, bar supplied - 0.4 inch diam. Wire sample - 0.083 inch diam., 7.88 inch G.L.	99.5					0.5Mg	253
263	Cold drawn 25%, electrolytic tough pitch. Bar sample - 0.505 inch diam., crosshead speed = 1/4 inch/minute, 2 inch G.L.							263
316i	Cold rolled 5 to 7% - 0.042mm. G.S. - after hot rolling and annealing 1150°F - 1/2 hr., electrolytic tough pitch. Sheet sample - 1/2 inch wide X 1/8 inch thick, tested parallel to rolling direction, 2 inch G.L.	99.90						316
316ℓ	Cold rolled 5 to 7% - 0.040mm. G.S. -after hot rolling and annealing 1150°F - 1/2 hr., oxygen-free high-conductivity. Sheet sample - 1/2 inch wide X 1/8 inch thick, tested parallel to rolling direction, 2 inch G.L.	99.96						316
316r	Cold rolled 5 to 7% - 0.047mm. G.S. - after hot rolling and annealing 1150°F - 1/2 hr., phosphorized. Sheet sample - 1/8 inch thick X 1/2 inch wide, tested parallel to rolling direction, 2 inch G.L.	99.90					0.02 - 0.04P	316
316u	Tested transverse to rolling direction. Other specifications same as 316i.	99.90						316
316w	Tested transverse to rolling direction. Other specifications same as 316ℓ.	99.96						316
316x	Tested transverse to rolling direction. Other specifications same as 316r.	99.90					0.02 - 0.04P	316

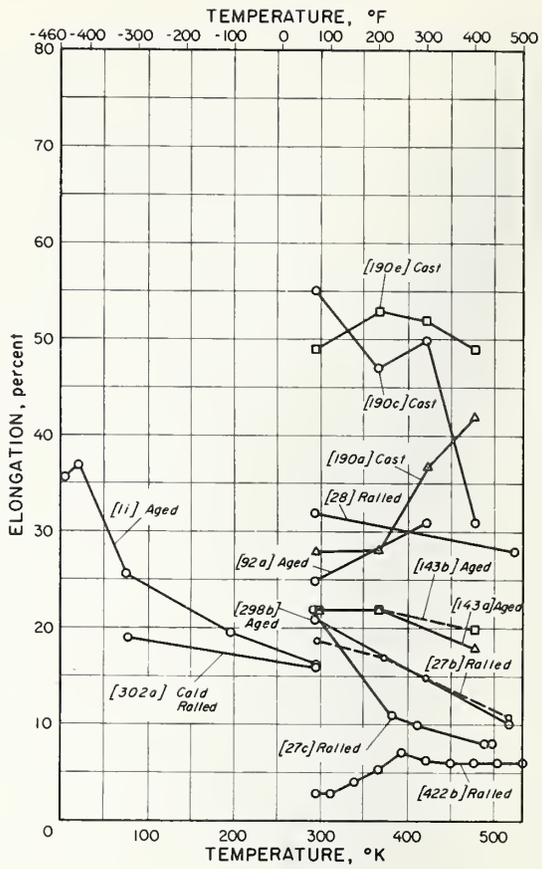


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1g	Cold drawn 60% - 0.287 to 2.00mm. G.S. - R_B = 45 to 53, oxygen-free high-conductivity, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, 1 inch G.L.	Bal		1ppm		4ppm	16ppm Ag, 12ppm S, 2ppm As, 5ppm Sb, <3ppm O	1
78c	Cold rolled to hard temper, plate supplied. Bar sample - reduced section - 2-1/2 inches long X 0.418 inch diam., crosshead speed = 0.25 inch/minute, 2 inch G.L.	98.60				0.78	0.45Si, 0.05Fe, 0.05P, 0.02As	78
91a	Hard. 1.97 inch G.L.	99.09		0.91				91
253a	Drawn 98.9% - from hot rolled bar, bar supplied - 1/4 inch diam. Wire sample - 0.110 inch diam., 7.88 inch G.L.							253
253b	Drawn 80.7% - from hot rolled rod, bar supplied - 1/4 inch diam. Wire sample - 0.110 inch diam., 7.88 inch G.L.							253
279b	Worked. 2 inch G.L.							279
285a	Hard drawn. Bar sample - 0.197 inch diam.							285
308	Drawn, electrolytic tough pitch. 2 inch G.L.	99.9					0.03O	308
316b	Cold drawn 21% - R_B = 45, bar supplied - 3/4 inch diam. 2 inch G.L.	99.79					0.21Te	316
316c	Cold drawn - R_B = 56, bar supplied - 3/4 inch diam. 2 inch G.L.	99.64					0.35Te	316
367a	Cold drawn 96%, electrolytic tough pitch, bar supplied - 0.25 inch diam. Wire sample - 0.025 inch diam., 212°F tests made in boiling water and 419°F tests made in hot Crisco, 2 tests/temp., 2 inch G.L.							367
367c	Cold drawn 64.5%, electrolytic tough pitch. Other specifications same as 367a.							367
465a	Hard (original condition). Wire sample - 0.197 inch diam., sample strained to hard condition - then tested after 1/4 hr., 1.97 inch G.L.							465
465b	Tested after 1 hr. Other specifications same as 465a.							465
465c	Tested after 256 hrs. Other specifications same as 465a.							465

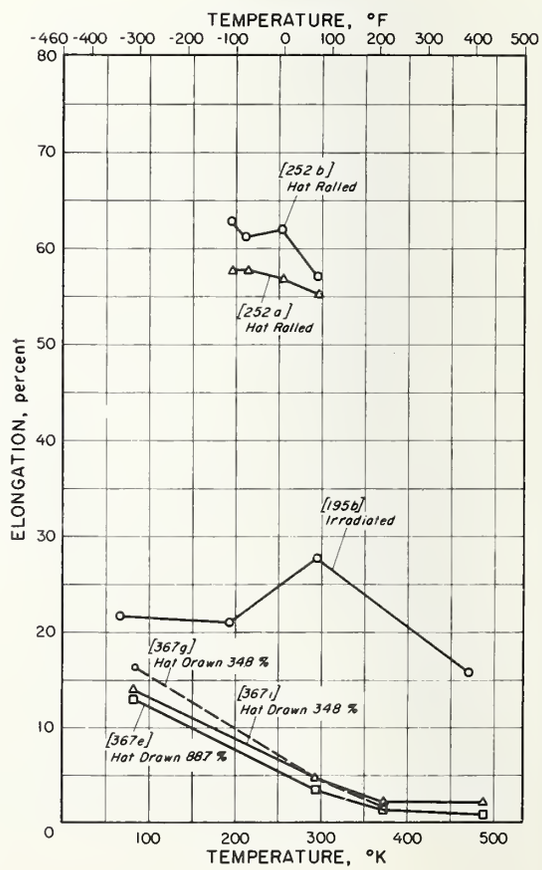


Tensile Elongation of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
1i	Aged 450°C - 1 hr. - 0.203mm. G.S. - R_B = 68 - after first heating to 950°C - water quenching - then cold drawing 85 - 90%, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, 1 inch G.L.	Bal	With the exception of Zr, these elements are approximate,	1ppm		4ppm	0.18Zr, 16ppm Ag, 12ppm S, 2ppm As, 5ppm Sb, < 3ppm O	1
27b	As rolled, electrolytic rough pitch, bar supplied - 1/2 inch diam. Bar sample - reduced section 2-1/2 inches long X 1/4 inch diam., stress rate constant: 1120 psi/minute, tested in CO_2, 2 inch G.L.	99.92					0.08O	27
27c	As rolled, bar supplied - 1/2 inch diam. Bar sample - reduced section - 2-1/2 inches long X 1/4 inch diam., stress rate constant: 1120 psi/minute, tested in both air and hydrogen, but differences in test results negligible, 2 inch G.L.	99.54					0.13As, 0.13O, 0.01Pb, 0.08Sn, 0.02Fe	27
28	Rolled, bar supplied - 1/2 inch diam. Bar sample - reduced section - 2-1/2 inches long X 1/4 inch diam., 2 inch G.L.	99.84					0.08O, 0.01S	28
92a	Heated 1562°F - 1/2 hr. - water quenched. 1.97 inch G.L.	99.77					0.23Zr	92
143a	Aged 750 to 800°F - 1 to 2 hrs. - R_B = 48 - after cold drawing 75%, bar supplied - 3 inch diam. Bar sample - reduced section - 2.25 inches long X 0.48 inch diam., 2 inch G.L.	99.84					0.16Zr	143a
143b	R_B = 57. Other specifications same as 143a.	99.82					0.18Zr	143a
190a	As cast, electrolytic tough pitch. Bar sample, 2 tests/temp., 2 inch G.L.							190
190c	As cast, oxygen-free high-conductivity. Bar sample, 2 tests/temp., 2 inch G.L.							190
190e	As cast, phosphorized. 2 tests/temp., 2 inch G.L.							190
298b	Aged ("fully heat treated"), bar supplied - 3/4 inch diam. Crosshead speed = 0.1 inch/minute, 2 inch G.L.	99.4					0.6Cr	298
302a	Cold rolled. 2 inch G.L.							302
422b	Rolled. Bar sample - 0.72 inch diam.							422

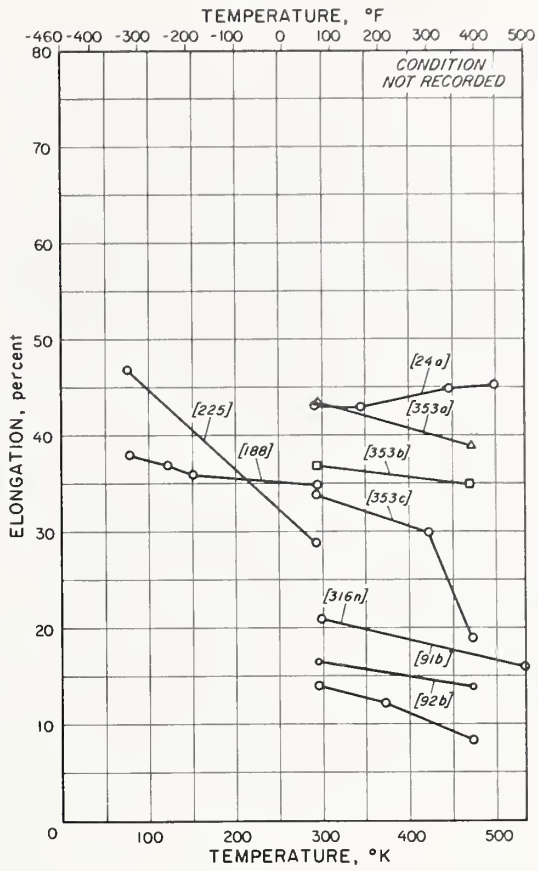


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
195b	Irradiated for six months at about 212°F in a flux of 6 X 10^{12} slow neutrons/cm^2/sec. - total dose was 5.1 X 10^{19} slow neutrons/cm^2 - after annealing 842°F - 1 hr. - 0.010 to 0.015 mm G.S., oxygen-free high-conductivity, 2 inch G.L.							195
252a	Hot rolled, electrolytic tough pitch, bar supplied - 1.58 inches square, 3.94 inch G.L.	99.96 99.98						252
252b	Hot rolled, bar supplied - 1.58 inches square, 3.94 inch G.L.	99.5					0.5Mg	252
367e	Drawn at 302°F - 88.7%, electrolytic tough pitch, bar supplied - 0.25 inch diam. Wire sample - 0.025 inch diam., 212°F tests made in boiling water and 419°F tests made in hot Crisco, 3 tests at -310°F - 2 tests each at other temps, 2 inch G.L.							367
367g	Drawn at 302°F - 34.8%, electrolytic tough pitch. 5 tests at -310°F. Other specifications same as 367e.							367
367i	Drawn at 392°F - 34.8%, electrolytic tough pitch. 4 tests at -310°F - 3 tests at 212°F. Other specifications same as 367e.							367



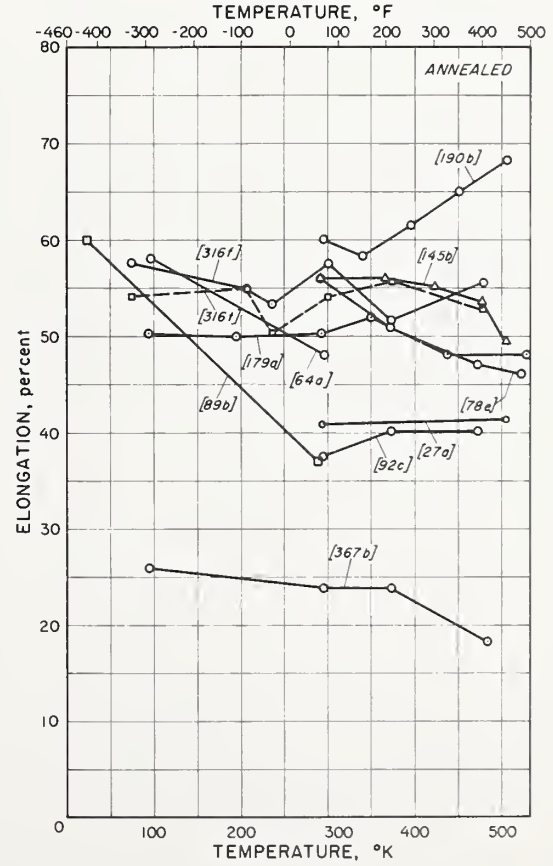
Tensile Elongation of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
24a	2 inch G. L.	99.9						24
91b	1.97 inch G. L.	99.71					0.29	91
92b	1.97 inch G. L.	99.32					0.68Cr	92
188	Notched (Tipper) - 0.76 X 0.61 inch at notch - approx. 0.01 inch notch radius - 45° ($K_T \approx 6.2$), 2 inch G. L.	99.50					0.37As, 0.07P, 0.04Ni	188
225		99.8						225
316n	R_B = 38, oxygen-free high-conductivity, bar supplied - 3/4 inch diam., 2 inch G. L.	99.96						316
353a	Oxygen-free high-conductivity, sheet supplied - 0.030 inch thick. Strain rate = 5 to 10 inches/inch/hr., 1 inch G. L.	99.93						353
353b	Strain rate = 0.4 inch/inch/hr. Other specifications same as 353a.	99.98						353
353c	Strain rate = 0.002 inch/inch/hr. Other specifications same as 353a.	99.98						353



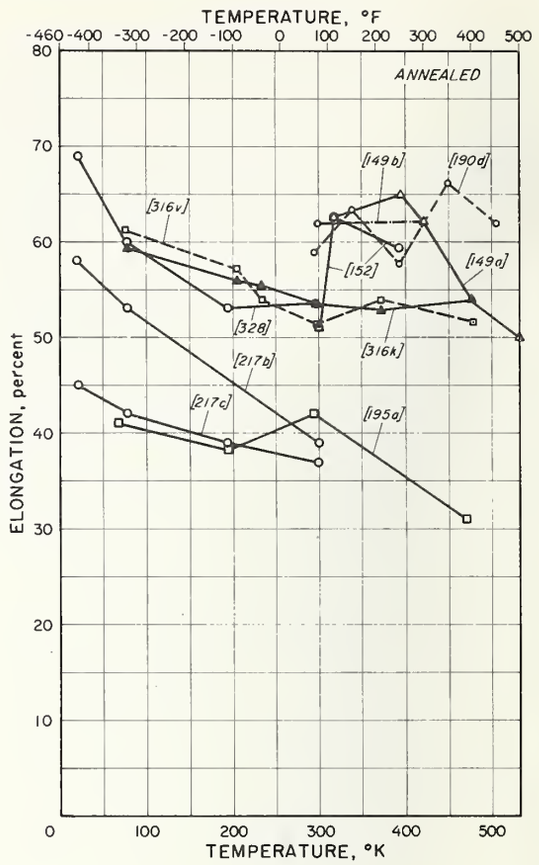
Tensile Elongation of Copper (Electrolytic Tough Pitch)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
27a	Annealed 1382°F - CO_2 atmos. - 2 hrs., bar supplied - 1/2 inch diam. Bar sample - reduced section - 2-1/2 inches long X 1/4 inch diam., stress rate constant: 1120 psi/minute, tested in CO_2 atmos., 2 inch G. L.	99.92					0.08O	27
64a	Annealed.							64
78e	Annealed 1382°F - after hot rolling, plate supplied. Bar sample - reduced section - 2-1/2 inches long X 0.418 inch diam., crosshead speed = 0.25 inch/minute, 2 inch G. L.	99.91				0.03	0.04O, 0.01As	78
89b	Annealed 1382°F - water quenched. Bar sample - 0.118 inch diam., 1.18 inch G. L.	99.7						89
92c	Soft.							92
145b	Annealed 1112°F - 2 hrs. Bar sample - reduced section - 2 inches long X 0.5 inch diam., 2 inch G. L.							145
179a	Annealed 1292°F - 1/2 hr. in nitrogen. Bar sample - 0.177 inch diam., 1.97 inch G. L.							179
190b	Annealed 600°F - 1/2 hr. - after rolling at 1200°F, electrolytic tough pitch. Bar sample - 2 tests/temp. except at 150 and 350°F, 2 inch G. L.							190
316f	Annealed 1150°F - 1/2 hr. - 0.040mm. G. S. - after hot rolling. Sheet sample - 1/2 inch wide X 1/8 inch thick, tested parallel to rolling direction, 2 inch G. L.	99.90						316
316t	Tested transverse to rolling direction. Other specifications same as 316f.	99.90						316
367b	Annealed 1382°F - 5 minutes - after cold drawing 96%, bar supplied - 0.25 inch diam. Wire sample - 0.025 inch diam., 212°F tests made in boiling water and 419°F tests made in hot Crisco, 3 tests at 212°F - 2 tests each at other temps., 2 inch G. L.							367



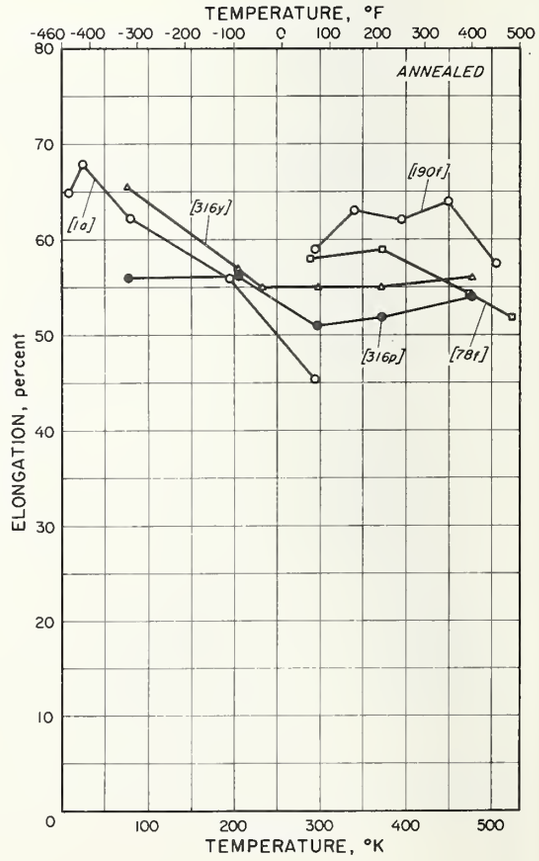
Tensile Elongation of Copper (Oxygen-Free High-Conductivity)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
149a	Annealed - 0.025mm. G.S. Bar sample - reduced section - 2 inches long X 0.505 inch diam., strain rate ≈0.01 inch/inch/minute, 2 inch G.L.	99.99						149
149b	Annealed - 0.12mm. G.S. Other specifications same as 149a	99.99						149
152	Annealed - 0.025mm. G.S. - R_F = 34.0. Bar sample - 0.505 inch diam., rate of loading = 3200 psi/hr. (3200 psi applied at 1 hr. intervals), 2 inch G.L.	99.99						152
190d	Annealed 600°F - 1/2 hr. - after rolling at 1200°F. Bar sample, 2 tests/temp. except at 150 and 350°F, 2 inch G.L.							190
195a	Annealed 842°F-1 hr. - 0.010 to 0.015mm. G.S. - after drawing 64%, wire supplied - 0.080 inch diam. Wire sample - 6 inches long X 0.048 inch long, strain rate = 0.000382 inch/inch/sec., 2 inch G.L.	99.99						195
217b	Annealed 392°F- 8 hrs., He atmos. - 0.014mm. G.S. - after receiving annealed. Foil sample - 0.010 inch thick X 1/2 inch wide - long axis parallel to rolling direction, strain rate ≈0.0005 inch/inch/minute to yield and ≈0.02 inch/inch/minute beyond, 4 tests at 80°F and -423°F and 5 tests at -323°F, 2 inch G.L.							217
217c	Annealed - 0.011mm. G.S. - R_F = 49. Wire sample - square - 0.080 inch, strain rate ≈0.0005 inch/inch/minute to yield and ≈0.02 inch/inch/minute beyond, 3 to 8 testr/temp., 1, 2 inch G.L.							217
316k	Annealed 1150°F - 1/2 hr. - 0.045mm. G.S. - after rolling. Sheet sample - 1/2 inch wide X 1/8 inch thick, tested parallel to rolling direction, 2 inch G.L.	99.96						316
316v	Tested transverse to rolling direction. Other specifications same as 316k.	99.96						316
328	Annealed (soft) - ASTM G.S.# = 5 - R_H = 86, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1 1/4 inches long X 0.174 inch reduced diam., 2 tests each at 70° and -108°F - 3 tests each at -323° and -423°F, crosshead speed was either 0.2 or 0.02 inches/minute at all temps., 0.708 inch G.L. (4 X diam.).	Copper and Silver =					99.99	328



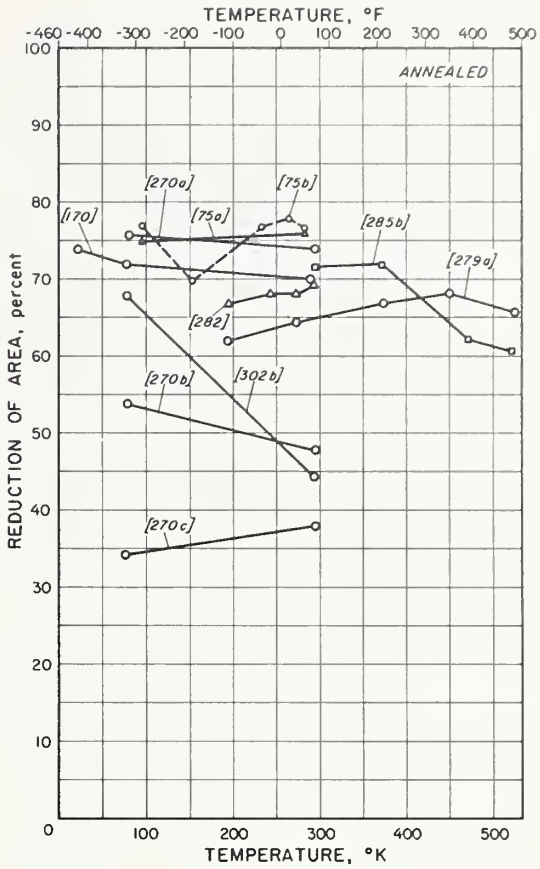
Tensile Elongation of Copper (Phosphorized)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
1a	Annealed 1100°F - 1 hr. - 0.036mm. G.S. - R_E = 35, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long - 0.247 inch diam. at middle - 0.250 inch diam. at ends, crosshead speed = 0.02 inch/minute, 1 inch G.L.	99.97					0.03P	1
78f	Annealed 1382°F - after hot rolling, plate supplied. Bar sample - reduced section - 2-1/2 inches long X 0.418 inch diam., crosshead speed = 0.25 inch/minute, 4 inch G.L.	99.92				0.02	0.05P, 0.01As	78
190f	Annealed 600°F - 1/2 hr. - after rolling at 1200°F. Bar sample, 2 tests/temp. except at 150 and 350°F, 2 inch G.L.							190
316p	Annealed 1150°F - 1/2 hr. - 0.045mm. G.S. - after hot rolling. Sheet sample - 1/8 inch thick X 1/2 inch wide, tested parallel to rolling direction, 2 inch G.L.	99.90					0.02 - 0.04P	316
316y	Tested transverse to rolling direction. Other specifications same as 316p.	99.90					0.02 - 0.04P	316

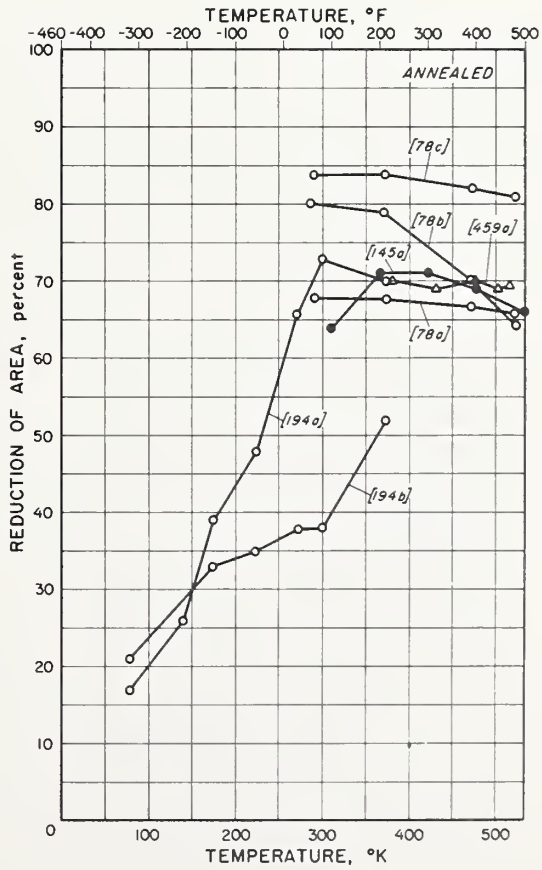


Tensile Reduction of Area of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
75a	Annealed. Bar sample - 0.504 inch diam.	99.93						75
75b	Annealed. Bar sample - 0.25 inch diam.	99.98						75
170	Annealed, bar supplied - 0.315 to 0.394 inch diam. Bar sample -0.118 inch diam.	99.9						170
270a	Annealed 930°F - 1 hr. - air cooled. Bar sample - 0.212 inch diam., crosshead speed = 0.05 inch/minute, <0.001 inch between sample axis and loading axis.							270
270b	Bar sample - notched: 0.212 inch diam. at notch - <0.001 inch notch radius ($K_t \approx 10.3$) - 60° notch angle - 0.233 inch outer diam., values refer to reduction at notch. Other specifications same as 270a.							270
270c	0.286 inch outer diam. Other specifications same as 270b.							270
279a	Soft.							279
282	Annealed 1472°F - 1/2 hr. - bar supplied - 5/8 inch diam. Bar sample - 0.394 inch diam.	99.75						282
285b	Annealed 1202°F - 1/2 hr. Bar sample - 0.197 inch diam.							285
302b	Annealed	99.9						302

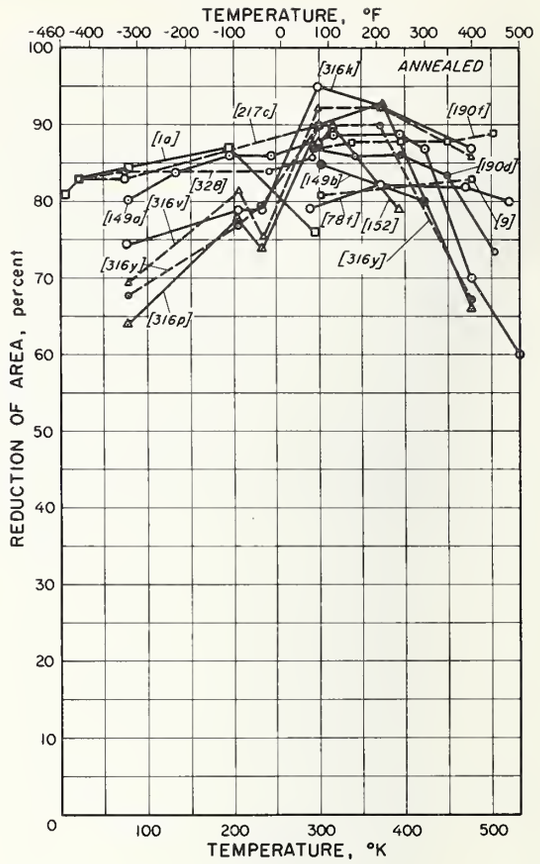


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
78a	Annealed 1382°F - after hot rolling, plate supplied. Bar sample - reduced section - 2-1/2 inches long × 0.418 inch diam., crosshead speed = 0.25 inch/minute.	99.45				0.03	0.4As, 0.06P	78
78b	Annealed 1382°F - after hot rolling, plate supplied. Bar sample - reduced section - 2-1/2 inches long × 0.418 inch diam., crosshead speed = 0.25 inch/minute.	99.51					0.38As, 0.05O, 0.03Ni	78
78c	Cold rolled to hard temper, plate supplied. Bar sample - reduced section - 2-1/2 inches long × 0.418 inch diam., crosshead speed = 0.25 inch/minute.	98.60				0.78	0.45Si, 0.05Fe, 0.05P, 0.02As	78
145a	Annealed 1112°F - 2 hrs. Bar sample - reduced section - 2 inches long × 0.5 inch reduced diam.	99.75					0.23As	145
194a	Annealed 1202°F - 1 hr. - cooled to 212°F at rate of 50°F/hr., after first annealing 1247°F - 36 hrs. - then swaging 36% at 1508°F - then cold swaging 36% - then cold drawing 27%, prepared from electrolytic copper and antimony. Bar sample - 0.212 inch diam., 6 tests/temp., strain rate = 0.05 inches/inch/minute.						0.5Sb	194
194b	Strain rate = 19,000 inches/inch/minute. Other specifications same as 194a.						0.5Sb	194
459a	Annealed 1157°F - 2-2/3 hrs. - pickled. Wire sample - 0.114 inch diam., constant load applied while wire was heated at 36.0°F per minute until sample broke, same results for 5.4°F per minute.	99.95					0.04O	459

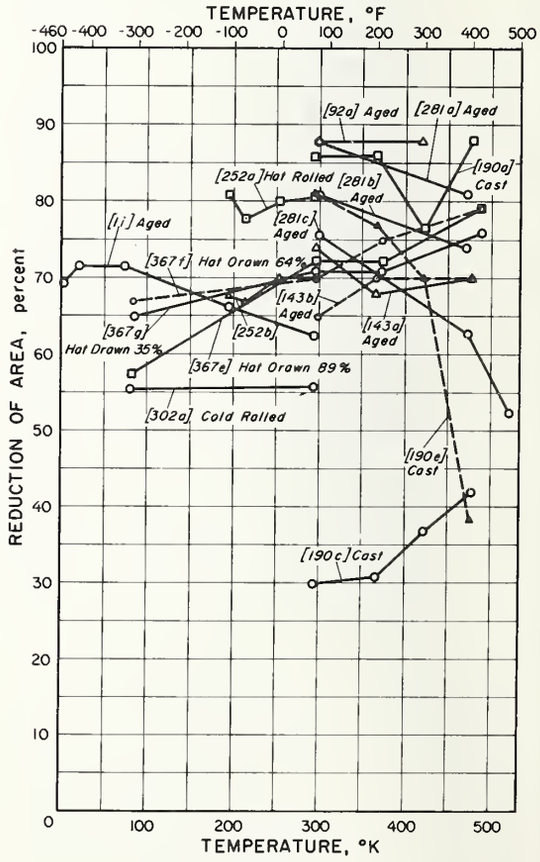


Tensile Reduction of Area of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1100°F - 1 hr. - 0.036mm. G.S. - R_F = 35, phosphorized, bar supplied - 3/4 inch diam. Bar sample - 0.250 inch diam. at ends - 0.247 inch diam. at center, crosshead speed = 0.02 inch/minute.	99.97					0.03P	1
9	Annealed - R_B = 34, phosphorized, bar supplied - 3/4 inch diam.	99.97					0.02P	9
78f	Annealed 1382°F - after hot rolling, phosphorized, plate supplied. Bar sample - reduced section - 2-1/2 inches long X 0.418 inch diam., crosshead speed = 0.25 inch/minute.	99.92				0.03	0.05P, 0.01As	78
149a	Annealed 0.025mm. G.S., oxygen-free high-conductivity. Bar sample - reduced section - 2 inches long X 0.505 inch diam., strain rate ≈0.01 inches/inch/minute.	99.99						149
149b	Annealed - 0.12mm. G.S. Other specifications same as 149a.	99.99						149
152	Annealed-0.025mm. G.S. - R_F = 34.0, oxygen-free high-conductivity. Bar sample - 0.505 inch diam., rate of loading = 3200 psi/hr. (3200 psi applied at 1 hr. intervals).	99.99						152
190d	Annealed 600°F - 1/2 hr. - after rolling 1200°F, oxygen-free high-conductivity. Bar sample, 2 tests/temp. except at 150 and 350°F.							190
190f	Annealed 600°F - 1/2 hr. - after rolling 1200°F, phosphorized. Bar sample, 2 tests/temp. except at 150 and 350°F.							190
217c	Annealed - 0.01mm. G.S. - R_F = 49, oxygen-free high-conductivity. Wire sample - 0.080 inch square, strain rate ≈ 0.0005 inch/inch/minute to Y.S. and ≈0.02 inch/inch/minute beyond, 2 to 7 tests/temp.							217
316k	Annealed 1150°F - 1/2 hr. - 0.045mm. G.S - after hot rolling, oxygen-free high-conductivity. Sheet sample - 1/2 inch wide X 1/8 inch thick, tested parallel to rolling direction.	99.96						316
316p	Annealed 1150°F - 1/2 hr. - 0.045mm G.S - after hot rolling, phosphorized. Sheet sample - 1/8 inch thick X 1/2 inch wide, tested parallel to rolling direction.	99.90					0.02 - 0.04P	316
316v	Tested transverse to rolling direction. Other specifications same as 316k.	99.96						316
316y	Tested transverse to rolling direction. Other specifications same as 316p.	99.90					0.02 - 0.04P	316
328	Annealed (soft) - ASTM G.S. # = 5 - R_H = 86, oxygen-free high conductivity, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1-1/4 inches long X 0.174 inch reduced diam., 4 tests/temp. at 3 temps., 5 tests at -323°F, crosshead speed either 0.2 or 0.02 inches/minute at all temps.	Copper + Silver = 99.99						328

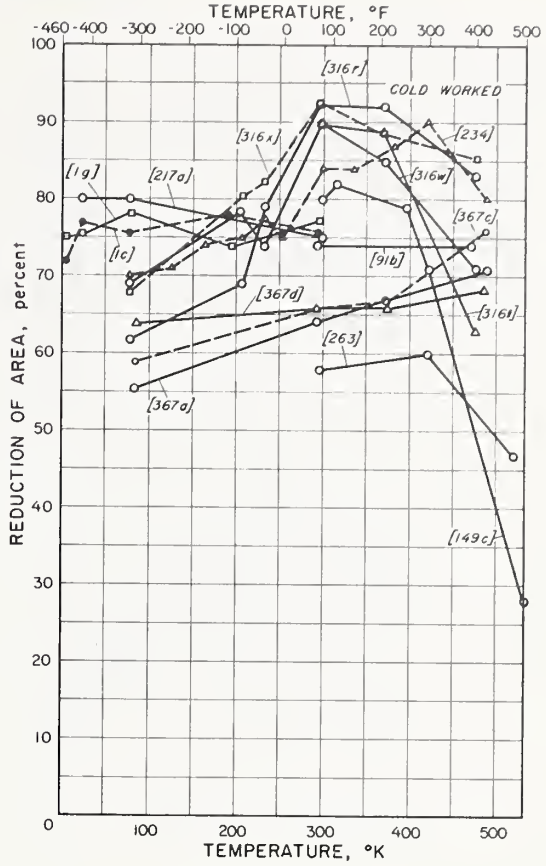


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1i	Aged 450°C - 1 hr. - 0.203mm. G.S. - R_B = 68 - after first heating to 950°C - water quenching - then cold drawing 85 - 90%, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute.	Bal		1ppm		4ppm	0.18Sr, 16ppm Ag, 12ppm S, 2ppm As, 5ppm Sb, <3ppm O	1
		With the exception of Zr, these elements are approximate.						
92a	Heated 1562°F - 1/2 hr. - water quenched.	99.77					0.23Zr	92
143a	Aged 750 to 800°F - 1 to 2 hrs. - R_B = 48 - after cold drawing 75%, bar supplied - 3 inch diam. Bar sample - reduced section - 2.25 inches long X 0.48 inch reduced diam.	99.84					0.16Zr	143
143b	R_B = 57. Other specifications same as 143a.	99.82					0.18Zr	143
190a	As cast, electrolytic tough pitch - Bar sample, measurements difficult because of distorted pieces, 2 tests/temp.							190
190c	As cast, oxygen-free high-conductivity. Bar sample, measurements difficult because of distorted pieces, 2 tests/temp.							190
190e	As cast, phosphorized - Bar sample, measurement difficult because of distorted pieces, 2 tests/temp.							190
252a	Hot rolled, electrolytic tough pitch, bar supplied - 1.58 inches square.	99.96 99.98						252
252b	Hot rolled, bar supplied - 1.58 inches square.	99.5					0.5Mg	252
281a	Aged at 752°F - after cold drawing 54%. Bar sample - 0.25 inch diam., crosshead speed = 0.02 inch/minute.	99.85					0.15Zr	281
281b	Aged at 707°F - after cold drawing 84%. Bar sample - 0.25 inch diam., crosshead speed = 0.02 inch/minute.	99.85					0.15Zr	281
281c	Aged 842°F - after cold drawing 84%. Bar sample - 0.25 inch diam., crosshead speed = 0.02 inch/minute.	99.3					0.7Cr	281
302a	Cold rolled.	99.9						302
367e	Drawn at 302°F - 88.7%, electrolytic tough pitch, bar supplied - 0.25 inch diam. Wire sample - 0.025 inch diam. 212°F tests made in boiling water and 419°F tests made in hot crisco, 3 tests at - 310°F - 2 tests each at other temps.							367
367f	Drawn at 302°F - 64.5%, electrolytic tough pitch. 3 tests each at room temperature and 212°F. Other specifications same as 367e.							367
367g	Drawn at 302°F - 34.8%, electrolytic tough pitch. 5 tests at -310°F. Other specifications same as 367e.							367

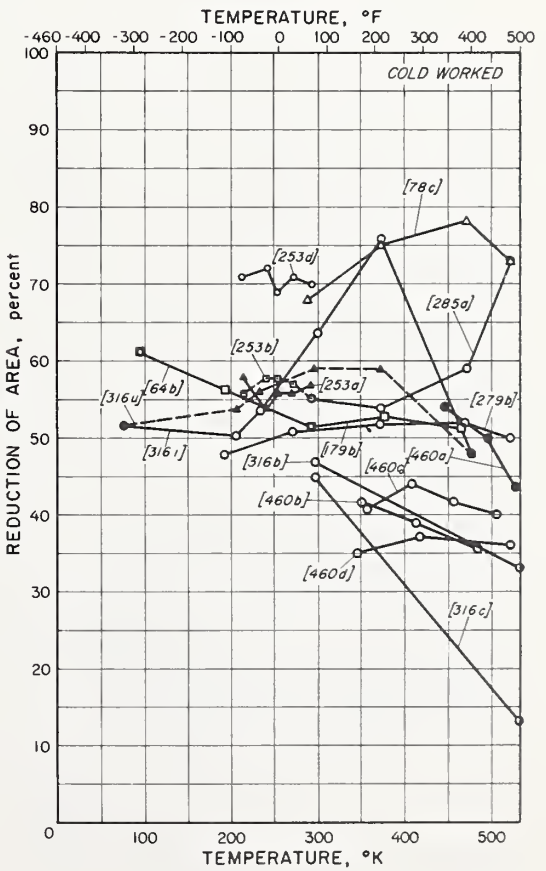


Tensile Reduction of Area of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1c	Cold drawn 26% - 0.144mm. G.S. - R_B = 50, phosphorized, bar supplied - 3/4 inch diam. Bar sample - 0.250 inch diam. at ends - 0.247 inch diam. at center, crosshead speed = 0.02 inch/minute.	99.97					0.03P	1
1g	Cold drawn 60% - 0.287 to 2.00mm. G.S. - R_B = 45 to 53, oxygen-free high-conductivity, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long × 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute.	Bal		1ppm		4ppm	16ppm Ag, 12ppm S, 2ppm As, 5ppm Sb, <3ppm O.	1
91b		99.71					0.29	91
149c	Drawn 40%, oxygen-free high-conductivity. Bar sample - reduced section - 2 inches long × 0.505 inch diam., strain rate ≈0.01 inch/inch/minute.	99.99						149
217a	Drawn - R_B = 57, oxygen-free high-conductivity. Bar sample 1/4 inch diam., strain rate ≈0.0005 inch/inch/minute to Y.S. and ≈0.02 inch/inch/minute beyond, 2 tests/temp.							217
234	Cold rolled 5 to 7%, phosphorized. Plate sample - 1/4 inch thick - cut parallel to rolling direction, crosshead speed = 0.0059 inch/minute to Y.S. and 0.119 inch/minute to U.T.S., 2 to 3 tests/temp.							234
263	Cold drawn 25%, electrolytic tough pitch. Bar sample - 0.505 inch diam., crosshead speed = 1/4 inch/minute.							263
316ℓ	Cold rolled 5 to 7% - 0.040mm. G.S. - after hot rolling and annealing 1150°F - 1/2 hr., oxygen-free high-conductivity. Sheet sample - 1/2 inch wide × 1/8 inch thick, tested parallel to rolling direction.	99.96						316
316r	Cold rolled 5 to 7% - 0.047mm. G.S. - after hot rolling and annealing 1150°F - 1/2 hr., phosphorized. Sheet sample - 1/8 inch thick × 1/2 inch wide, tested parallel to rolling direction.	99.90					0.02 - 0.04P	316
316w	Tested transverse to rolling direction. Other specifications same as 316ℓ.							316
316x	Tested transverse to rolling direction. Other specifications same as 316r.	99.90					0.02 - 0.04P	316
367a	Cold drawn 96%, electrolytic tough pitch, bar supplied - 0.25 inch diam. Wire sample - 0.025 inch diam. - 212°F tests made in boiling water and 419°F tests made in hot Crisco, 2 tests/temp.							367
367c	Cold drawn 64.5%, electrolytic tough pitch. Other specifications same as 367a.							367
367d	Cold drawn 34.8%, electrolytic tough pitch. Other specifications same as 367a.							367

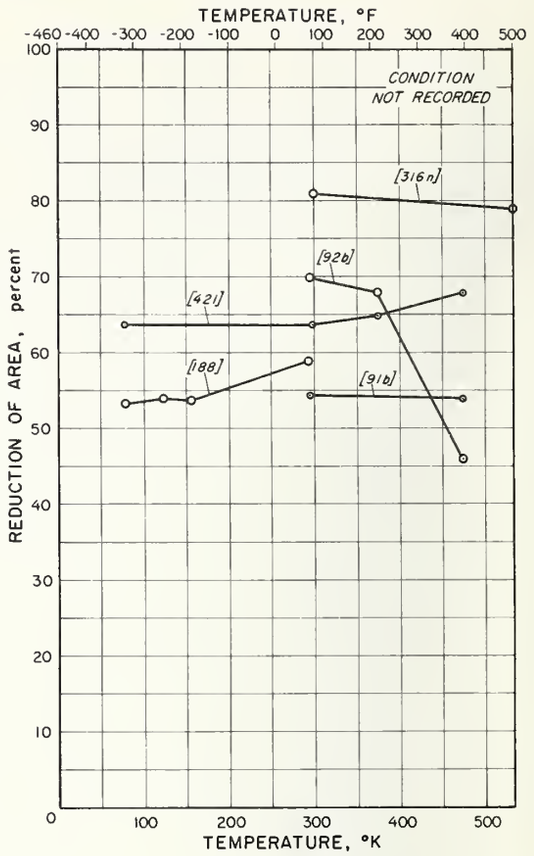


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
64b	Drawn 50%, electrolytic tough pitch.							64
78c	Cold rolled to hard temper, plate supplied. Bar sample - reduced section - 2-1/2 inches long × 0.418 inch diam., crosshead speed = 0.25 inch/minute.	98.60				0.78	0.45Si, 0.05Fe, 0.05P, 0.02As	78
179b	Cold worked, electrolytic tough pitch. Bar sample - 0.177 inch diam.							179
253a	Drawn 88.9% - from hot rolled rod, bar supplied - 1/4 inch diam. Wire sample - 0.110 inch diam.							253
253b	Drawn 80.7% from hot rolled rod, bar supplied - 1/4 inch diam. Wire sample - 0.110 inch diam.							253
253d	Drawn 95.6%, bar supplied - 0.4 inch diam. Wire sample - 0.083 inch diam.	99.5					0.5Mg	253
279b	Worked.							279
285a	Hard drawn. Bar sample - 0.197 inch diam.							285
316b	Cold drawn 21% - R_B = 45, bar supplied - 3/4 inch diam.	99.89					0.21Te	316
316c	Cold drawn - R_B = 56, bar supplied - 3/4 inch diam.	99.64					0.35Te	316
316i	Cold rolled 5 to 7% - 0.042mm. G.S. - after hot rolling and annealing 1150°F - 1/2 hr., electrolytic tough pitch. Sheet sample - 1/2 inch wide × 1/8 inch thick, tested parallel to rolling direction.	99.90						316
316u	Tested transverse to rolling direction. Other specifications same as 316i.	99.90						316
460a	Cold drawn 24.9%, wire supplied - 0.114 inch diam. Wire sample - 0.099 inch diam., constant load applied while wire was heated at 36°F per minute until sample broke.	99.72					0.18O, 0.10Pb	460
460b	Cold drawn 42.4%. Wire sample - 0.086 inch diam. Other specifications same as 460a.	99.72					0.18O, 0.10Pb	460
460c	Cold drawn 50.8%. Wire sample - 0.080 inch diam. Other specifications same as 460a.	99.72					0.18O, 0.10Pb	460
460d	Cold drawn 74.8%. Wire sample - 0.057 inch diam. Other specifications same as 460a.	99.72					0.18O, 0.10Pb	460



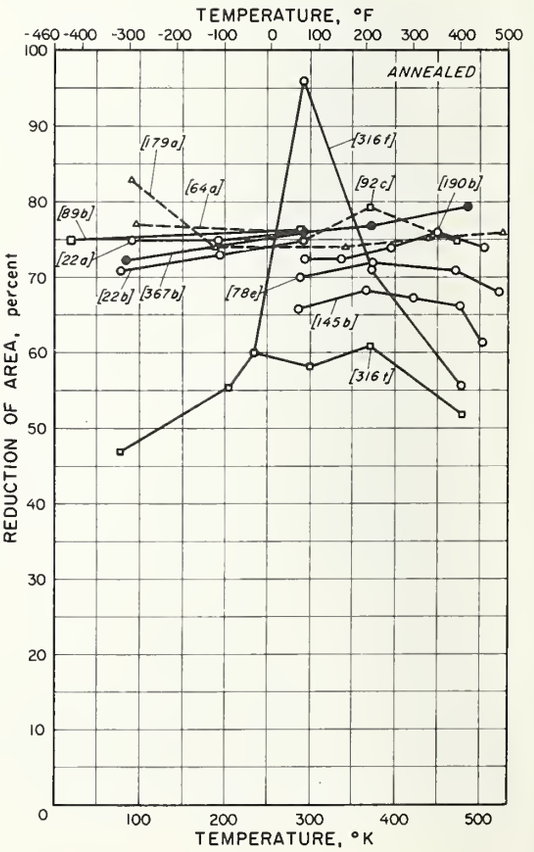
Tensile Reduction of Area of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
91b		99.71					0.29	91
92b		99.32					0.68Cr	92
188	Plate sample - notched (Tipper) - 0.76 X 0.61 inch at notch - approx. 0.01 inch notch radius - 45° ($K_t \approx 6.2$).	99.50					0.37As, 0.07P, 0.04Ni	188
316n	R_B = 38, oxygen-free high-conductivity, bar supplied - 3/4 inch diam.	99.96						316
421	Bar sample.							421



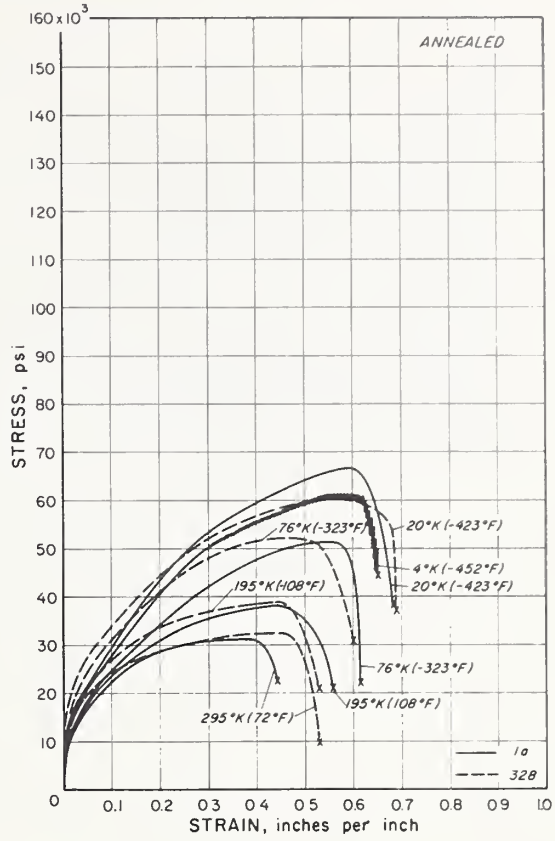
Tensile Reduction Area of Copper (Electrolytic Tough Pitch)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
22a	Annealed 932°F - air cooled. Bar sample - 0.138 inch diam., strain rate ≈0.001 inch/inch/sec.	99.9						22
22b	Annealed 932°F - air cooled. Bar sample - 0.138 inch diam., strain rate ≈100 inches/inch/sec.	99.9						22
64a	Annealed.							64
78e	Annealed 1382°F - after hot rolling, plate supplied. Bar sample - reduced section - 2-1/2 inch long X 0.418 inch diam., crosshead speed = 0.25 inch/minute.	99.91				0.03	0.04O, 0.01As	78
89b	Annealed 1382°F - water quenched. Bar sample - 0.118 inch diam.	99.7						89
92c	Soft.							92
145b	Annealed 1112°F - 2 hrs. Bar sample - reduced section - 2 inches long X 0.5 inch diam.							145
179a	Annealed 1292°F - 1/2 hr. in nitrogen. Bar sample - 0.177 inch diam.							179
190b	Annealed 600°F - 1/2 hr. - after rolling at 1200°F. Bar sample, 2 tests/temp. except at 150 and 350°F.							190
316f	Annealed 1150°F - 1/2 hr. - 0.040mm. G.S. - after hot rolling. Sheet sample - 1/2 inch wide X 1/8 inch thick, tested parallel to rolling direction.	99.90						316
316t	Tested transverse to rolling direction. Other specifications same as 316f.	99.90						316
367b	Annealed 1382°F - 5 minutes - after cold drawing 96%, bar supplied - 0.25 inch diam. Wire sample - 0.025 inch diam. 212°F tests made in boiling water and 419°F tests made in hot crisco, 3 tests at 212°F - 2 tests each at other temps.							367

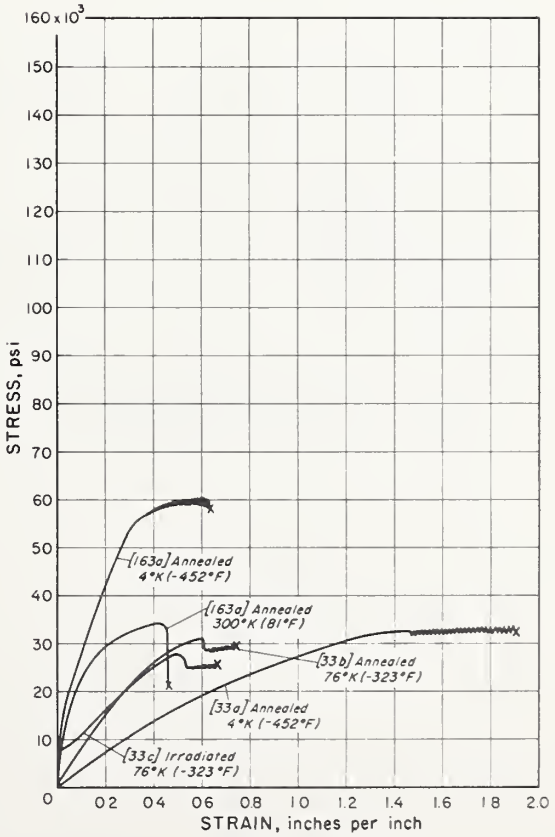


Tensile Stress-Strain Curves of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
1a	Annealed 1100°F - 1 hr. - 0.036mm. G.S. - R_F = 35, phosphorized, bar supplied - 3/4 inch diam. Bar sample - 0.250 inch at ends - 0.247 inch at center, crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer, 1 inch G.L.	99.97					0.03P	1
328	Annealed (soft) - ASTM G.S. # = 5 - R_H = 86, oxygen-free high-conductivity, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1-1/4 inch long × 0.174 inch reduced diam., crosshead speed was either 0.2 or 0.02 inches/minute at all temps., clamp-on strain gage extensometer, 1 inch G.L.		Copper + Silver = 99.99					328

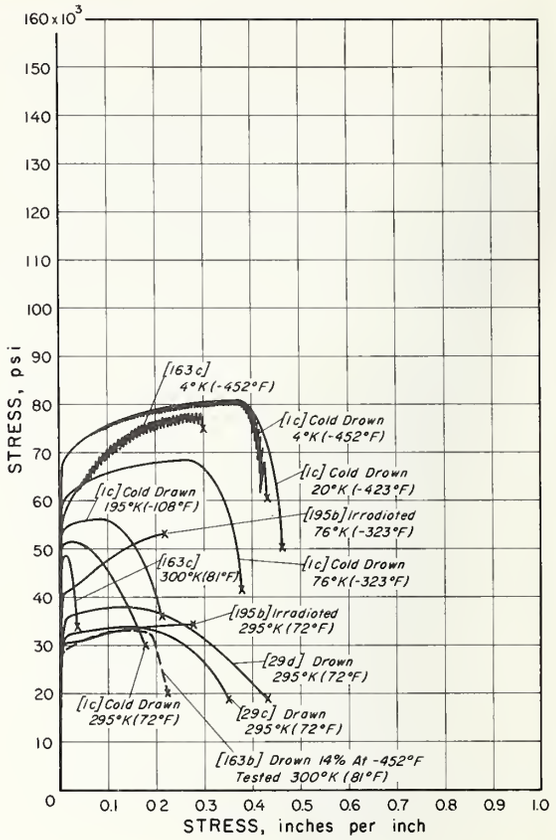


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
33a	Annealed, single crystal - orientation near [511]. Sample area = 0.0114 inches^2, 0.584 inch G.L., discontinuous slip - last part of curve.	99.999						33
33b	Annealed, single crystal - orientation near [221]. Sample area = 0.0179 inches^2, 1.51 inches G.L., twinning last part of curve.	99.999						33
33c	Irradiated 10^{18}nvt (neutrons/cm^2) - after annealing, single crystal - orientation near [221]. Sample area = 0.0195 inches, 1.52 inches G.L., twinning last part of curve.	99.999						33
163a	Annealed.	99.9						163

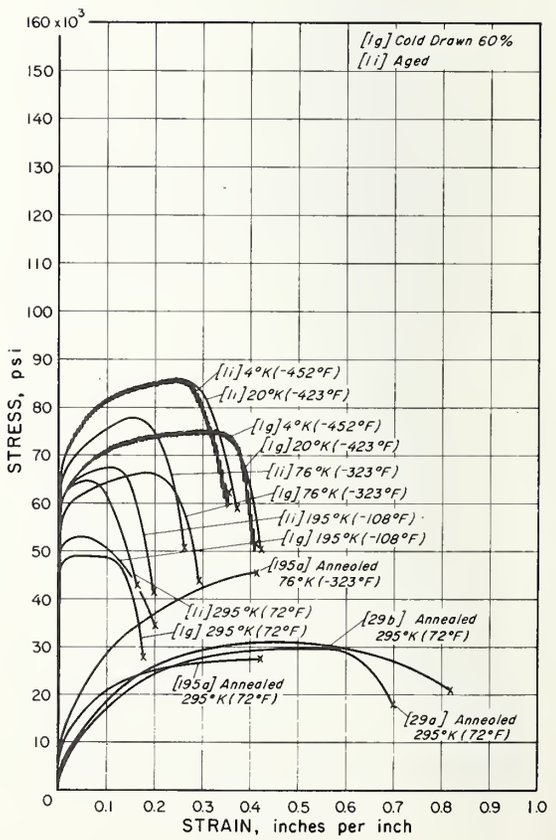


Tensile Stress-Strain Curves of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1c	Cold drawn 26% - 0.144mm. G.S. - R_B = 50, phosphorized, bar supplied - 3/4 inch diam. Bar sample - 0.250 inch at ends - 0.247 inch at center, crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer, 1 inch G.L.	99.97					0.03P	1
29c	Drawn, oxygen-free high-conductivity. Bar sample - approx. 6 inches long - 0.564 inch reduced diam. - surface not polished, strain rate ≈0.04 inch/inch/minute.							29
29d	Strain rate ≈5.0 inches/inch/minute. Other specifications same as 29c.							29
163b	Drawn 14% at -452°F then unloaded and warmed to 81°F in 17 minutes.	99.9						163
163c	"Unannealed".	99.9						163
195b	Irradiated for six months at approx. 212°F in a flux of 6×10^{12} slow neutrons/cm^2/sec., total dose was 5.1×10^{19} slow neutrons/cm^2 - after annealing, oxygen-free high-conductivity, wire supplied, 0.080 inch diam. Wire sample - 0.048 inch diam. X 6 inches long, strain rate = 0.000082 inch/inch/sec.	99.99						195

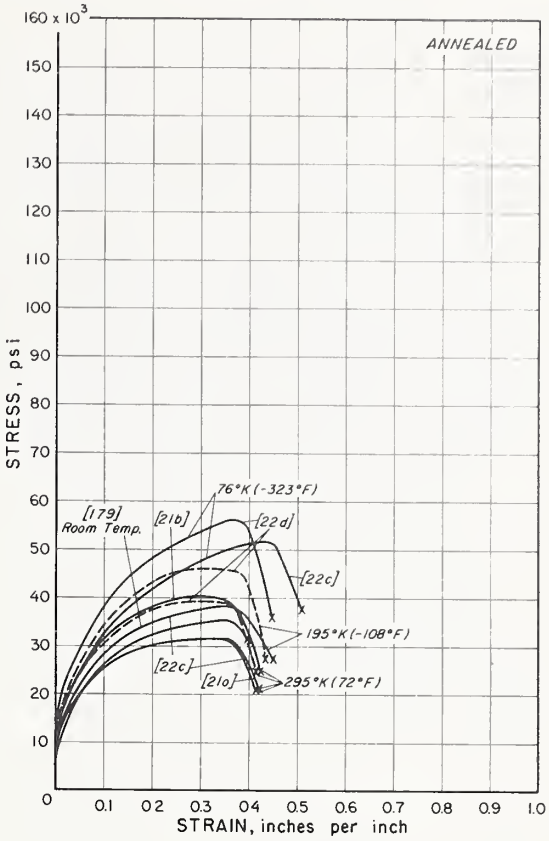


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
1g	Cold drawn 60% - 0.287 to 2.00mm. G.S. - R_B = 45 to 53, oxygen-free high-conductivity, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, clamp-on, strain gage extensometer, 1 inch G.L.	Bal		1ppm		4ppm	16ppm Ag, 12ppm S, 2ppm As, 5ppm Sb, <3ppm O.	1
1i	Aged 450°C - 1 hr. - 0.203mm. G.S. - R_B = 68 - after first heating to 950°C - water quenching - then cold drawing 85 - 90%. Other specifications same as 1g.	Bal	Other elements approx. same as for 1g.				0.18Zr	1
29a	Annealed 1112°F - 1/2 hr. in pure nitrogen, oxygen-free high-conductivity. Bar sample - approx. 6 inches long - 0.564 inch reduced diam. - surface not polished, strain rate ≈0.04 inch/inch/minute.							29
29b	Strain rate ≈ 5.0 inches/inch/minute. Other specifications same as 29a.							29
195a	Annealed 842°F - 1 hr. - 0.010 to 0.015mm. G.S. - after drawing 64%, wire supplied - 0.080 inch diam., oxygen-free high-conductivity. Wire sample - 0.048 inch diam. X 6 inches long, strain rate = 0.000082 inch/inch/sec.	99.99						195



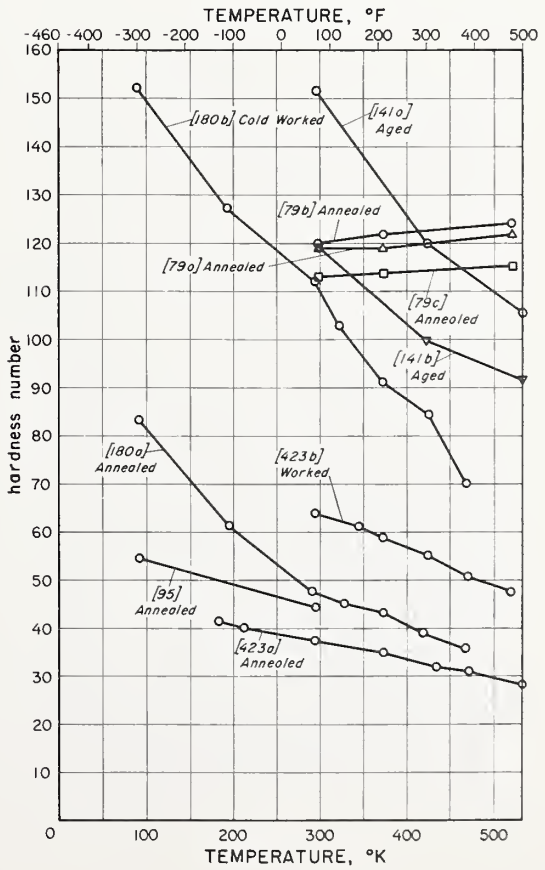
Tensile Stress-Strain Curves of Copper (Electrolytic Tough Pitch)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	At	Ni	Other	
21a	Annealed 1112°F. Strain rate ≈ 0.001 inch/inch/sec.							21
21b	Annealed 1112°F. Strain rate ≈ 100 inches/inch/sec.							21
22c	Annealed 932°F - air cooled. Bar sample - 0.138 inch diam., strain rate to U. T. S. = 0.0004 inch/inch/sec., 0.75 inch G. L.	99.9						22
22d	Strain rate to U. T. S. = 80 inches/inch/sec. Other specifications same as 22c.	99.9						22
179	Annealed. Bar sample - 0.177 inch diam.							179



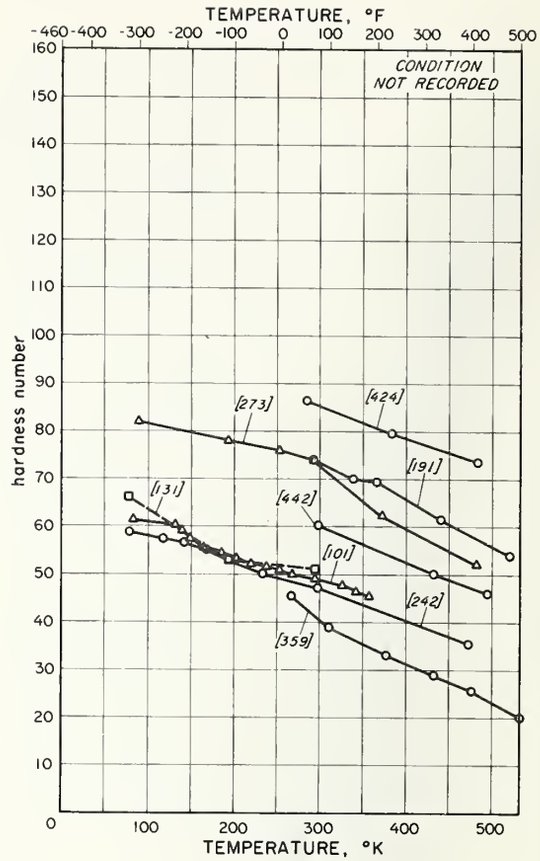
Hardness of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	At	Ni	Other	
79a	Annealed 1652°F - 1/2 hr. - after cold rolling 50%. Diamond pyramid hardness-10 kgm. load.	99.44		0.01		0.03	0.37As, 0.09O, 0.01Ag	79
79b	Annealed 1652°F - 1/2 hr. - after cold rolling 50%. Diamond pyramid hardness - 10kgm. load.	99.45		0.01		0.07	0.36As, 0.07P, 0.01Ag	79
79c	Annealed 1652°F - 1/2 hr. - after cold rolling 50%, electrolytic tough pitch. Diamond pyramid hardness - 10kgm load.	99.85		0.01		0.02	0.03O, 0.01Ag	79
95	Annealed 932°F. Strip sample - approx. 0.039 inch thick X approx. 0.1 inch cross-sectional area. Brinell hardness - steel ball - 0.0394 inch diam., tests at 68° and -297°F made on same strip.							95
141a	Aged 830°F - 16 hrs. - after annealing 1830°F - 15 minutes and cold rolling to R_B = 70. Diamond pyramid hardness.	99.2					0.8Cr	141
141b	Aged 800°F - 1 hr. - after annealing 1300°F - 20 minutes and cold rolling to R_B = 65. Diamond pyramid hardness.	99.75					0.25Zr	141
180a	Annealed 1292°F - 1 hr., electrolytic tough pitch. Cone indenter - 120° - 25 kgm. load - 5 minutes.							180
180b	Cold worked, electrolytic tough pitch. 120° - 25 kgm. load - 5 minutes.							180
423a	Soft. 400 kgm. load - ball indenter - 10mm. diam.							423
423b	Worked. 700 kgm. load - ball indenter - 10mm. diam.							423



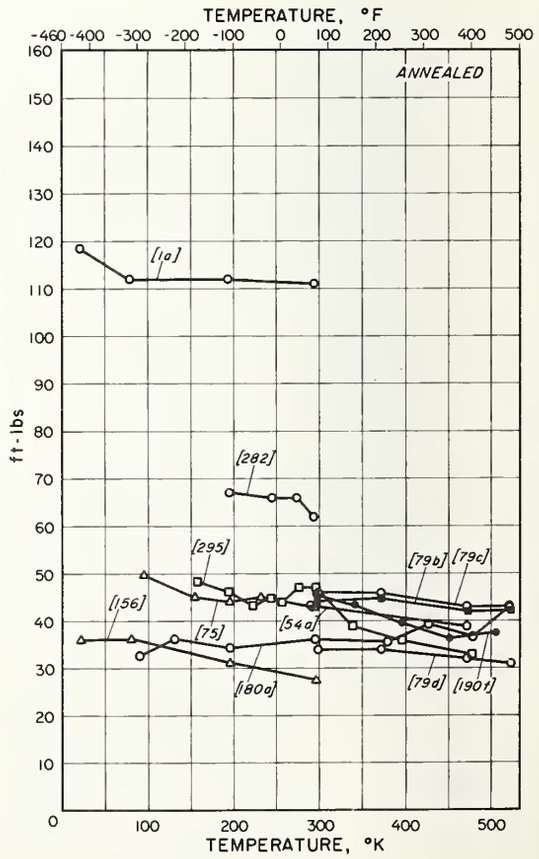
Hardness of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
101	10 to 150kgm.load - 120° cone indenter - diamond.							101
131	Brinell hardness - 3000kgm. load.	99.9						131
191	Electrolytic tough pitch. Cone indenter - 90° - 5 to 1000kgm. load - 15 sec.							191
242	Sample - 5/8 inch square - 2-1/2 inches long, Vickers diamond pyramid hardness, 4 tests/temp.							242
273	Brinell hardness - 3000kgm. load.							273
359	Oxygen-free high-conductivity. Disk sample - 1/2 to 1 inch diam. - 1/4 to 1/2 inch thick. Diamond pyramid hardness - 500gm. load.							359
424	"Dynamic hardness."							424
442	Electrolytic tough pitch. Cone indenter - 120° - diamond - 10 to 150kgm. load - 60 sec.							442



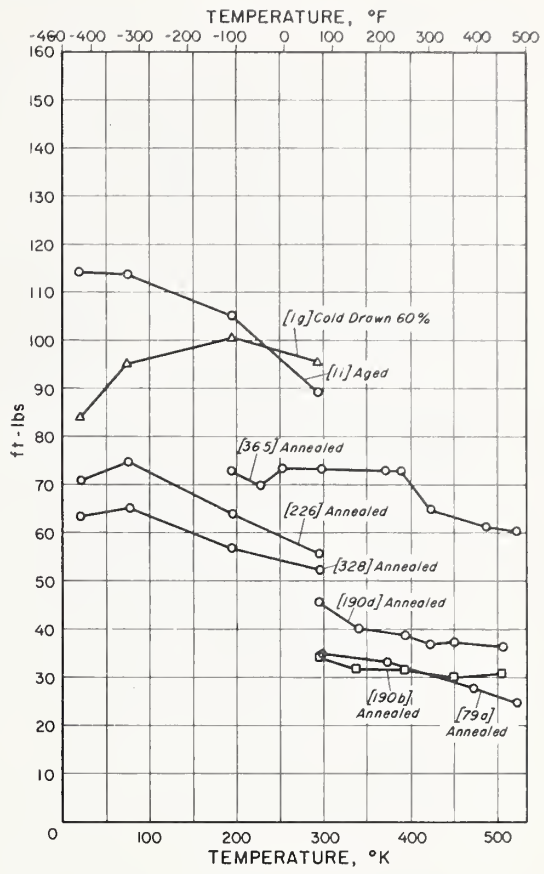
Impact Energy of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1100°F - 1 hr. - 0.036mm. G.S. - R_F = 35, phosphorized, bar supplied - 3/4 inch diam. Charpy V, hammer velocity = 16 ft./sec., paper container glued to sample used for -423°F, 50% fracture at -423°F - 20% fracture at other temps.	99.97					0.03P	1
54a	Annealed 1292°F - 4 hrs., chill - case ingot supplied - 1/2 inch thick. Izod, samples did not break - angle of bend = 65°.	99.0						54
75	Annealed. Izod, samples partly broken.	99.98						75
79b	Annealed - Vickers hardness = 48 (10kgm. load) - after cold rolling, phosphorized, plate supplied - 1 inch thick. Izod, sample cut parallel to rolling direction.	99.86		0.01		0.02	0.06P, 0.02As, 0.02Se + Te, 0.01Ag	79
79c	Annealed - Vickers hardness = 49 (10kgm. load) - after cold rolling, plate supplied - 1 inch thick. Izod, sample cut parallel to rolling direction.	99.45		0.01		0.07	0.36As, 0.07P, 0.01Ag	79
79d	Annealed - Vickers hardness = 52 (10 kgm. load) - after cold rolling, plate supplied - 1 inch thick. Samples cut parallel to rolling direction. Other specifications same as 79c.	99.44		0.01		0.08	0.37As, 0.09O, 0.01Ag	79
156	Soft, bar supplied - 3/4 inch square. Standard Charpy keyhole except for length: 2.0 inches, hammer velocity = 14.5 ft/sec., sample contained in paper boat at -323 and -423°F tests - correction applied, 1 to 3 tests/temp.							156
180a	Annealed 1292°F - 1 hr. in nitrogen, electrolytic tough pitch. Square sample - 0.315 (parallel to impact direction) X 0.394 X 3.94 inches, 45° sharp V-notch - 0.1185 inch deep, distance between supports = 1.575 inches, partial fracture - all temps.							180
190f	Annealed 603°F - 1/2 hr. - after rolling at 1200°F, phosphorized. Charpy keyhole, 2 tests/temp. except at 150 and 350°F.							190
282	Annealed 1472°F - 1/2 hr. Sample 0.394 X 0.394 X 3.94 inches - V notch.	99.75						282
295	Annealed - R_F = 43, phosphorized, bar supplied - 3/4 inch diam. Charpy keyhole, samples at - 175°F frozen in ether with liquid air and warmed to test temp., 3 tests/temp., samples unbroken.	99.95					0.03P	295

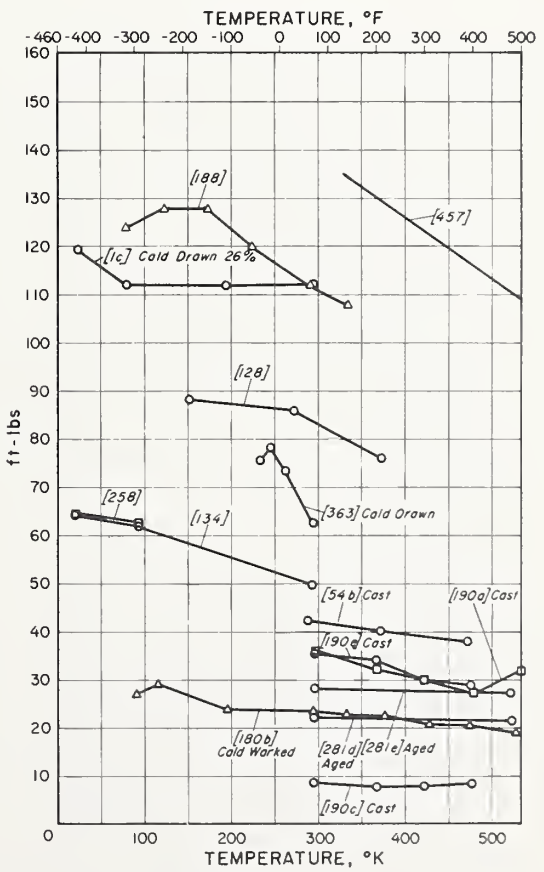


Impact Energy of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1g	Cold drawn 60% - 0.287 to 2.00mm, G.S. - R_B = 45 to 53, oxygen-free high-conductivity, bar supplied - 3/4 inch diam. Charpy V-notch, paper container glued to sample for -423°F tests, room temp.and -108°F tests: 30 or 90% fracture; -323°F: 10 or 90 or 95% fracture; -423°F: 95 or 100% fracture.	Bal		1ppm		4ppm	16ppm Ag, 12ppm S, 2ppm As, 5ppm Sb, < 3ppmO	1
1i	Aged 450°C - 1 hr. - 0.203mm, G.S. - R_B = 58 - after first heating to 950°C - water quenching - then cold drawing 85 - 90%. Room temp.: 88% fracture; -108°F: 90% fracture; -323°F: 85% fracture; -423°F: 97% fracture.	Bal	Other elements approx. same as 1g.				0.18Zr	1
79a	Annealed - Vickers hardness = 50 (10kgm. load) - after cold rolling, electrolytic tough pitch, plate supplied - 1 inch thick. Izod, samples cut parallel to rolling direction.	99.85		0.01		0.02	0.08O, 0.01Ag	79
190b	Annealed 600°F - 1/2 hr. - after rolling at 1200°F, electrolytic tough pitch. Charpy keyhole, 2 tests/temp - except at 150 and 350°F.							190
190d	Annealed 600°F - 1/2 hr. - after rolling at 1200°F, oxygen-free high-conductivity. Charpy keyhole, 2 tests/temp.- except at 150 and 350°F.							190
226	Annealed, oxygen-free high-conductivity. Sample cut longitudinally from bar, Charpy keyhole - paper boat container at -423°F, hammer velocity = 16 ft./sec., samples not broken - only deformed.							226
328	Annealed (soft)-ASTM G.S.#= 5 - R_H = 86, oxygen-free high-conductivity - bar supplied - 3/4 inch diam. Sample ASTM standard Charpy V-notch except for dimension parallel to notch which was 0.197 inch (1/2 standard width), 3 tests/temp., samples fractured 25% at all temps., paper boat container used for -423°F, values to the nearest 0.5 ft.-lb.	Copper + Silver =				99.99		328
365	Annealed 1202°F - 1 hr. - Brinell hardness = 48, electrolytic tough pitch. Sample ASTM standard Charpy V except for length: 2.36 inches, 75 to 212°F - tested in water; 212 to 482°F - tested in oil bath, 8 to 12 tests/temp. except at -54°F; 2 tests.	99.95					0.03O, 0.01Sb, 0.01As	365

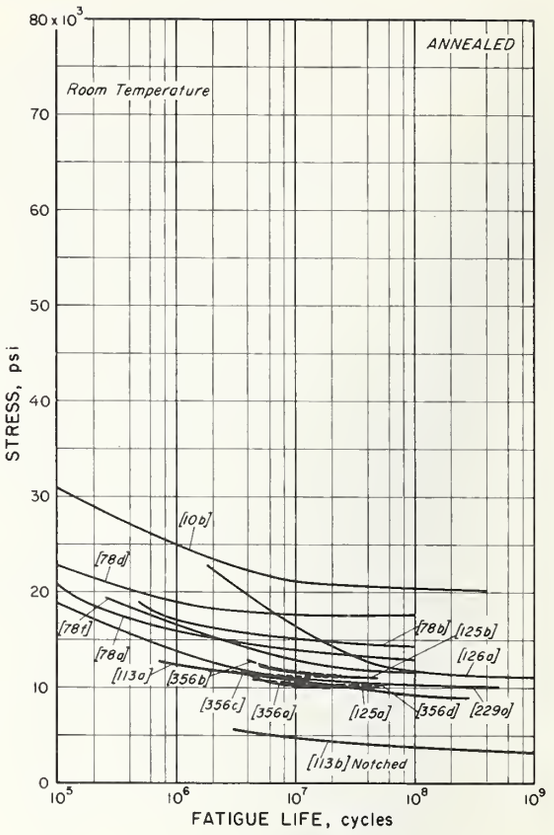


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1c	Cold drawn 26% - 0.144mm, G.S. - R_B = 50, phosphorized, bar supplied - 3/4 inch diam. Charpy V, hammer velocity = 16 ft./sec., paper container glued to sample for -423°F, 40% fracture at -423°F - 10% fracture at other temps.	99.97					0.03P	1
54b	Chill cast, chill-cast ingot supplied - 1/2 inch thick. Izod, samples did not break; angle of bend - 70° at 60 and 212°F and 65° at 392°F.	99.0						54
128	Sample assumed to be ASTM Charpy keyhole except for notch depth: 0.118 inch.							128
134	Sample ASTM standard Charpy keyhole except for dimension from back to notch bottom of 0.276 inch (ASTM = 0.197 inch), paper container for -423°F tests, samples did not fracture completely.	99.96						134
180b	Cold worked, electrolytic tough pitch. Square sample - 0.315 (parallel to impact direction) X 0.394 X 3.94, 45° sharp V-notch - 0.1185 inch deep, distance between supports = 1.575 inches, complete fracture - all temps.							180
188	Charpy V.	99.50					0.37As, 0.07P, 0.04Ni	188
190a	As cast, electrolytic tough pitch. Charpy keyhole - notch cut normal to columnar grains, 3 tests/temp.							190
190c	As cast, oxygen-free high-conductivity. Charpy keyhole - notch cut normal to columnar grains, 3 tests/temp.							190
190e	As cast, phosphorized. Charpy keyhole - notch cut normal to columnar grains, 3 tests/temp.							190
258	Sample ASTM standard Charpy keyhole except for notch depth: 0.118 inch, 2 tests/temp.	99.96						258
281d	Aged at 840°F - 1 hr. - after cold drawing 69%. Sample standard Charpy keyhole except for dimension normal to notch: 3/4 standard.	99.3					0.7Cr	281
281e	Aged at 750°F - 1 hr. - after cold drawing 69%. Sample standard Charpy keyhole except for dimension normal to notch: 3/4 standard.	99.85					0.15Zr	281
363	Cold drawn - Brinell hardness = 100 (500kgm. load), bar supplied - 1/2 inch square. Standard Izod sample except for cross-section: 7/16 inch square, striking velocity = 11 ft./sec., samples did not fracture.							363
457	Assumed type sample - Mesnager: U-notch - 0.079 inch deep X 0.079 inch wide; cross-section - 0.394 X 0.394 inch, author does not present point data.	99.93					0.02Fe, 0.01(Sn + Sb)	457

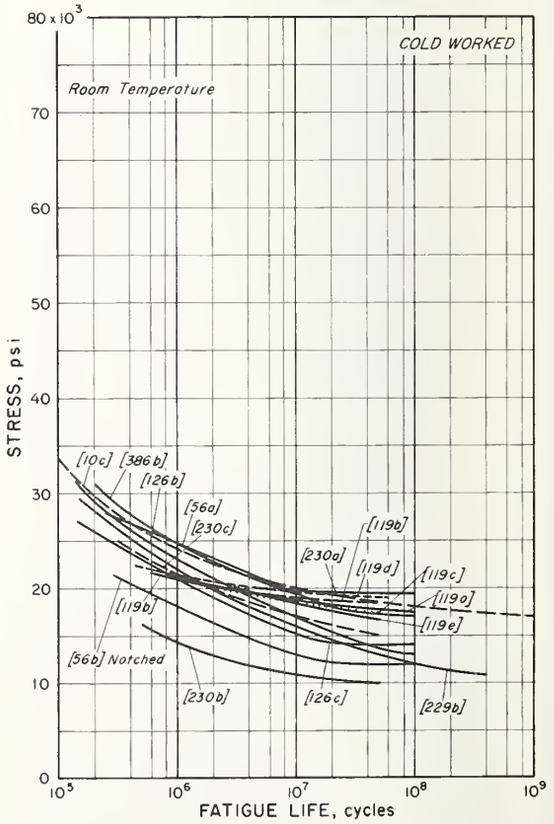


Fatigue Behavior of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
10b	Annealed 1202°F - 1 hr. - 0.015 to 0.020mm. G.S., room temp.: U.T.S. = 39,800 psi - Y.S. = 12,800 psi (0.2% offset) - R_F = 62, bar supplied - 0.5 inch diam. Bar sample - 0.3 inch reduced diam. - polished, rotating beam - 3500 r.p.m., sample at 19,000 psi - 7 X 10^8 cycles did not break.	98.64		0.60			0.74Cd, 0.01Mn, 0.01Si	10
78a	Annealed 1382°F - after hot rolling, plate supplied. Bar sample - reduced section - 2-1/4 inches long X 3/8 inch reduced diam., rotating beam - 2700 c.p.m., R = -1, sample at 12,300 psi - 10^8 cycles did not break.	99.45				0.03	0.40As, 0.06P	78
78b	Sample at 14,100 psi - 10^8 cycles did not break. Other specifications same as 78a.	99.51				0.03	0.38As, 0.05O	78
78d	Soft. Sample at 16,800 psi - 10^8 cycles did not break. Other specifications same as 78a.	98.60				0.78	0.45Si, 0.05Fe, 0.05P, 0.02As	78
78f	Phosphorized. Other specifications same as 78a.	99.92				0.03	0.05P, 0.01As	78
113a	Annealed 1112°F - 1 hr. - in vacuum, room temp.: U.T.S. = 32,500 psi., bar supplied. Bar sample - 0.325 inch diam. - cut longitudinally, axial stress - 8000 c.p.m., R = -1, test results essentially same on rotating beam samples - 0.3 inch diam.	99.4						113
113b	Plate sample - 2.5 inches wide - 0.25 inch thick - notched - 0.2 inch deep notch - 0.004 inch notch radius (K_T = 16.2) - 55° angle. Other specifications same as 113a.	99.4						113
125a	Annealed. Bar sample - 0.25 inch diam., uniaxial stress - 2200 c.p.s., R = -1, tested in air.							125
125b	Tested in damp nitrogen of 55% relative humidity. Other specifications same as 125a.							125
126a	Annealed, room temp.: U.T.S. = 31,400 psi. Sheet sample - uniform part = 2-3/16 X 3/16 X 0.020 inch, cut with rolling direction, reciprocating arm - 750 r.p.m., R = 1, 5 samples did not break at 9000 psi - 10^8 cycles.	99.95						126
229a	Annealed 1290°F - 30 minutes - pickled - after annealing 1290°F then drawing 26.4%, room temp.: U.T.S. = 32,400 psi. Bar sample - 0.4 inch reduced diam., rotating beam - 1500 r.p.m.	99.9						229
356a	Annealed. Bar sample - 0.5 inch reduced diam., 2200 c.p.m. tested in air.							356
356b	Tested in vacuum - 0.0005 to 0.001mm. Hg. Other specifications same as 356a.							356
356c	Tested in dry purified air, sample at 10,500 psi - 3 X 10^7 cycles did not break. Other specifications same as 356a.							356
356d	Tested in damp purified air of 55% relative humidity, samples at 9900 psi - 5 X 10^7 cycles did not break. Other specifications same as 356a.							356

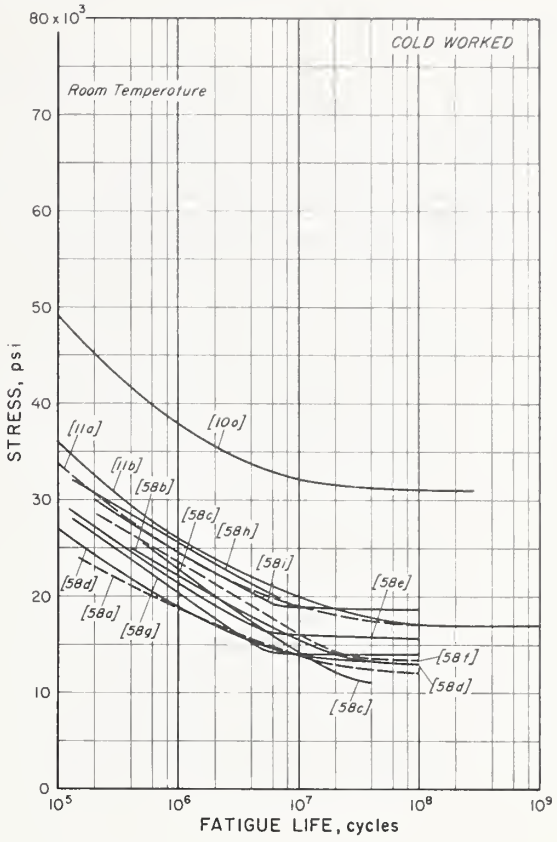


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
10c	Drawn 36% - 0.040mm. G.S., room temp.: U.T.S. = 48,800 psi - Y.S. = 46,500 psi (0.2% offset) - R_B = 47, electrolytic tough pitch, bar supplied - 0.5 inch diam. Bar sample - 0.3 inch reduced diam. - polished, rotating beam - 3500 r.p.m.	99.95					0.03O	10
56a	Drawn 30% - 0.040mm. G.S., room temp.: U.T.S. = 44,000 psi - Y.S. = 40,000 psi (0.2% offset), electrolytic tough pitch. Bar sample - 0.3 inch reduced diam. - polished, rotating cantilever - approx. 8000 r.p.m.	99.93						56
56b	Drawn 30% - 0.040mm. G.S. Notched bar sample - 0.30 inch diam. at notch - 0.0015 inch notch radius (K_T = 10.0) - 60°, rotating cantilever - approx. 8000 r.p.m.	99.93						56
119a	Drawn - room temp.: U.T.S. = 36,000 psi. Rotating beam - 2400 r.p.m.	99.92					0.05Fe, 0.02Mn, 0.01P	119
119b	Drawn 16.3%, room temp.: U.T.S. = 37,700 psi. Rotating beam - 2400 r.p.m.	99.95					0.04O	119
119c	Drawn 23.8%, room temp.: U.T.S. = 37,600 psi. Rotating beam - 2400 r.p.m.	99.94					0.05O	119
119d	Drawn 36%, room temp.: U.T.S. = 38,000 psi. Rotating beam - 2400 r.p.m.	99.90					0.09O	119
119e	Drawn 26%, room temp.: U.T.S. = 40,600 psi. Rotating beam - 2400 r.p.m.	99.75					0.24O	119
126b	Reduced 20.7% (B. & S. hardness = 2), room temp.: U.T.S. = 44,400 psi - R_B = 33.2. Sheet sample - uniform part = 2-3/16 X 3/16 X 0.020 inch, cut with rolling direction, reciprocating arm - 750 r.p.m., R = -1.	99.95						126
126c	Reduced 50.0% (B. & S. hardness = 6), room temp.: U.T.S = 52,600 psi - R_B = 55.3 Other specifications same as 126a.	99.93						126
229b	Drawn 56%, room temp.: U.T.S. = 56,200 psi. Bar sample 0.4 inch reduced diam., rotating beam - 1500 r.p.m. R = -1, data spread ± 15%.	99.9						229
230a	Drawn, room temp.: U.T.S. = 48,700 psi - ultimate shear strength = 33,300 psi - Brinell hardness = 96 (500 kgm. load) bar supplied - 3/4 inch diam. Bar sample - reduced section = 1-1/2 inches long X 0.35 inch reduced diam. - polished, torsion fatigue, R = 0.							230
230b	Torsion fatigue, R = 1. Other specifications same as 230a.							230
230c	Bar sample - 0.4 inch reduced diam. - polished, flexure fatigue, R = -1. Other specifications same as 230a.							230
386b	Cold drawn 36%, room temp.: U.T.S. = 50,500 psi - Y.S. = 48,600 psi (0.2% offset) - R_F = 85.5, electrolytic tough pitch. Rotating beam.	99.93						386

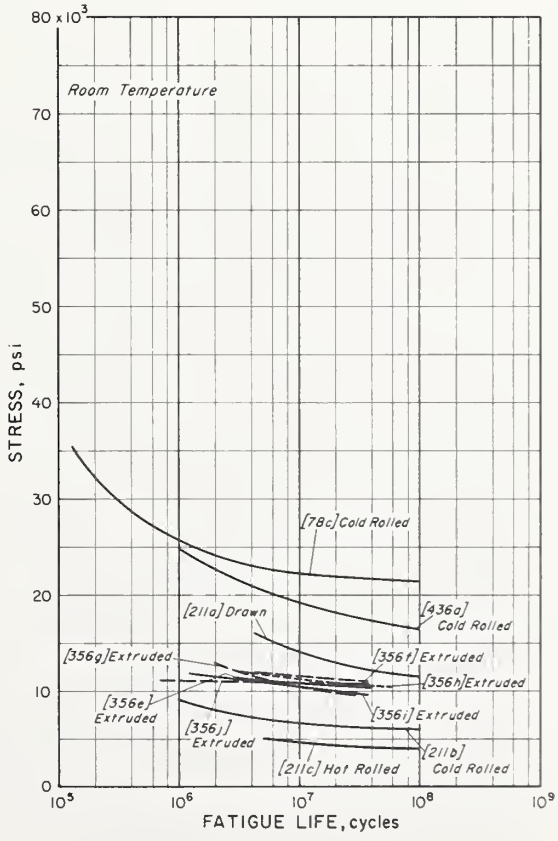


Fatigue Behavior of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
10a	Drawn 67% - 0.040mm. G.S., room temp.: U.T.S. = 76,700 psi - Y.S. = 73,800 psi (0.2% offset) - R_B = 73, bar supplied - 0.5 inch diam. Bar sample - 0.3 inch reduced diam., polished, rotating beam - 3500 r.p.m., sample at 30,000 psi - 6×10^8 cycles did not break.	98.67		0.52			0.81Cd	10
11a	Drawn 36% - 0.040mm. G.S., room temp.: U.T.S. = 48,800 psi - Y.S. = 46,500 psi (0.2% offset) - R_B = 47, electrolytic tough pitch. Bar sample - 0.3 inch reduced diam., rotating beam - 3500 r.p.m.	99.95					0.03O	11
11b	Drawn 29% - 0.125mm. G.S., room temp.: U.T.S. = 51,000 psi - Y.S. = 49,000 psi (0.2% offset) - R_B = 37, oxygen-free high-conductivity. Bar sample - 0.3 inch reduced diam., rotating beam - 3500 r.p.m.	99.95					0.03O	11
58a	Reduced 21% - 0.030mm. G.S., room temp.: U.T.S. = 41,000 psi - R_B = 34, electrolytic tough pitch. Strip sample - tapered part - 3-9/32 inches long × 3/16 inch wide - cut with rolling direction, rotating cantilever - 900 r.p.m., sample at 11,500 psi - 10^8 cycles did not break.	99.93						58
58b	Reduced 37% - 0.030mm. G.S., room temp.: U.T.S. = 49,300 psi - R_B = 48, electrolytic tough pitch. Sample at 13,500 psi - 10^8 cycles did not break. Other specifications same as 58a.	99.93						58
58c	Reduced 60% - 0.030mm. G.S., room temp.: U.T.S = 57,700 psi - R_B = 58, electrolytic tough pitch. Other specifications same as 58a.	99.93						58
58d	Reduced 21% - 0.040mm. G.S., room temp.: U.T.S. = 41,400 psi - R_B = 40, phosphorized. Bar sample - 0.3 inch reduced diam. - polished, cantilever beam - approx. 8000 r.p.m., samples at 12,500 and 14,000 psi - 10^8 cycles did not break.	99.97					0.01P	58
58e	Reduced 37% - 0.045mm. G.S., room temp.: U.T.S. = 45,300 psi - R_B = 50, phosphorized. Samples at 15,000 psi - 10^8 cycles did not break. Other specifications same as 58a.	99.97					0.01P	58
58f	Reduced 60% - 0.040mm. G.S., room temp.: U.T.S. = 51,600 psi - R_B = 58, phosphorized. Samples at 13,000 - 14,500 - 17,000 psi - 10^8 cycles did not break. Other specifications same as 58a.	99.97					0.01P	58
58g	Reduced 21% - 0.030mm. G.S., room temp.: U.T.S. = 42,800 psi - R_B = 37, phosphorized. Samples at 13,000 - 15,000 - 17,000 psi - 10^8 cycles did not break. Other specifications same as 58a.	99.96					0.03P	58
58h	Reduced 37% - 0.025mm. G.S., room temp.: U.T.S. = 51,600 psi - R_B = 51, phosphorized. Other specifications same as 58a.	99.96					0.03P	58
58i	Reduced 60% - 0.030mm. G.S., room temp.: U.T.S. = 59,300 psi - R_B = 61, phosphorized. Other specifications same as 58a.	99.96					0.03P	58

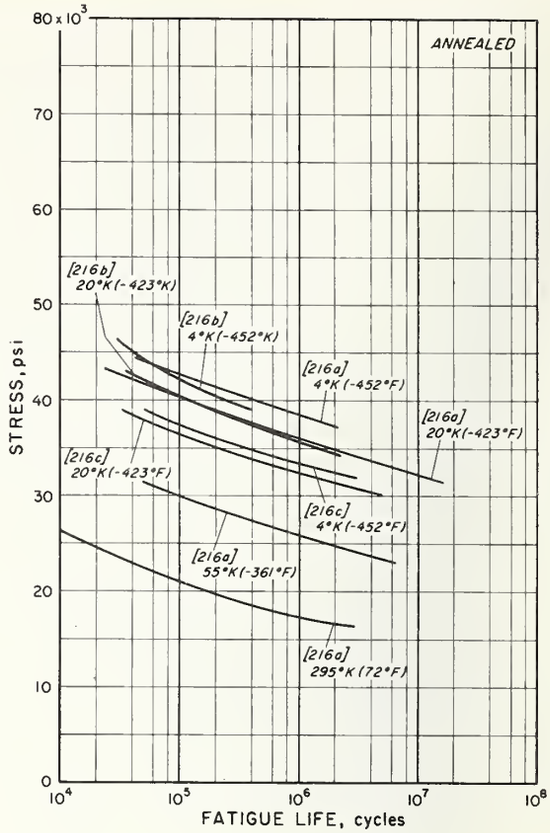


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
78c	Cold rolled to hard temper, plate supplied. Bar sample - reduced section - 2-1/4 inches long × 3/8 inch reduced diam., rotating beam - 2700 c.p.m., sample at 21,200 psi - 10^8 cycles did not break.	93.60				0.78	0.45Si, 0.05Fe, 0.05P, 0.02As	78
211a	Cold drawn, room temp.: U.T.S. = 40,400 psi, electrolytic tough pitch, bar supplied - 1 inch diam. Bar sample - reduced section - 2 inches long × 0.469 inch reduced diam., rotating cantilever - 1800 r.p.m., R = -1, data spread ± 8%.						0.02Fe	211
211b	Cold rolled, room temp.: U.T.S. = 40,400 psi, electrolytic tough pitch. Bar sample - reduced section - 4.5 inches long × 0.5 inch diam., alternating torsion, 2140 c.p.m., data spread ± 12%.						0.01Fe	211
211c	Hot rolled, room temp.: U.T.S. = 31,400 psi. Data spread ± 10%. Other specifications same as 211b.						0.01Fe	211
356e	Extruded to 71% reduction of area, room temp.: U.T.S. = 31,300 psi, electrolytic tough pitch, bar supplied - 3/4 inch diam. Bar sample - 0.5 inch reduced diam., 2200 c.p.m., tested in air, sample at 9,930 psi - 3×10^7 cycles did not break.	99.92					0.04O	356
356f	Tested in vacuum - 0.0005 to 0.001mm. Hg. Other specifications same as 356e.	99.92					0.04O	356
356g	Extruded to 78% reduction of area, room temp.: U.T.S. = 32,200 psi, oxygen-free high-conductivity, bar supplied - 3/4 inch diam. Bar sample - 0.5 inch reduced diam., 2200 c.p.m., tested in air.	99.96						356
356h	Tested in vacuum, 0.0005 to 0.001mm. Hg. Other specifications same as 356g.	99.96						356
356i	Extruded to 80% reduction of area, room temp.: U.T.S. = 32,900 psi, phosphorized, bar supplied - 3/4 inch diam. Bar sample - 0.5 inch reduced diam., 2200 c.p.m., tested in air.	99.96					0.02P	356
356j	Tested in vacuum - 0.0005 to 0.001mm. Hg., sample at 10,100 psi - 3×10^7 cycles did not break. Other specifications same as 356i.	99.96					0.02P	356
436a	Cold rolled, room temp.: U.T.S. = 52,000 psi, Y.S. = 21,500 psi, electrolytic tough pitch. Rotating cantilever.						0.01Fe	436

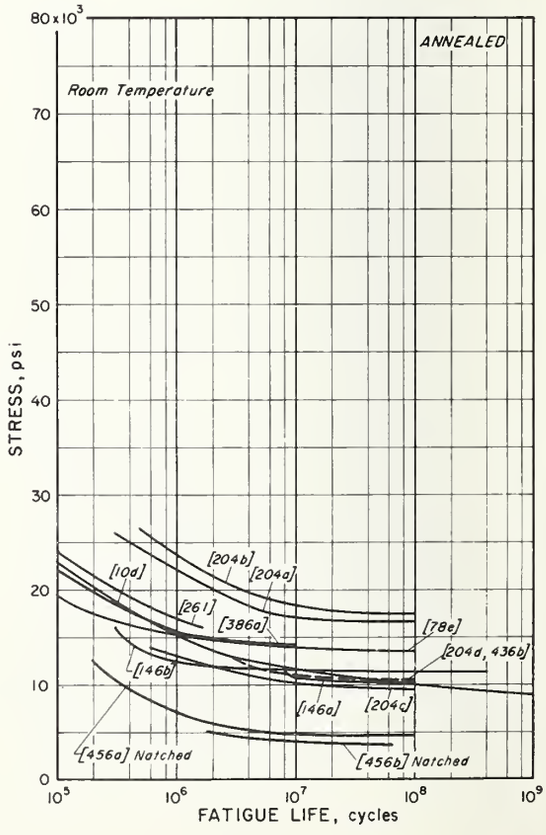


Fatigue Behavior of Copper (Electrolytic Tough Pitch)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
216a	Annealed 1112°F - "several hrs." - Ar atmos. Wire sample - 0.02 inch reduced diam., uniaxial stress - one end fixed - other end driven by vibrating generator, fixed stress at 225c.p.s., R = -1.						0.03O	216
216b	Applied stress built up gradually to indicated stress. Other specifications same as 216a.						0.03O	216
216c	Full stress applied immediately. Other specifications same as 216a.						0.03O	216

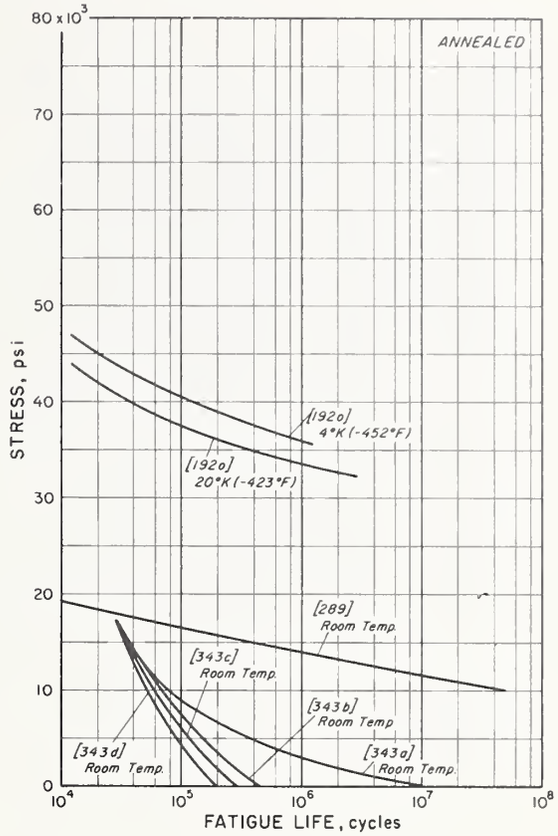


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
10d	Annealed 1112°F - 1-1/4 hrs. - 0.040mm. G.S., room temp.: U.T.S. = 31,100 psi - Y.S. = 4,800 psi (0.2% offset) - R_F = 43, bar supplied - 0.5 inch diam. Bar sample - 0.3 inch reduced diam. - polished, rotating beam - 3500 r.p.m., samples at 6,500 and 7,500 psi - 10^5 cycles did not break.	99.95					0.03O	10
78e	Annealed 1382°F - after hot rolling, plate supplied. Bar sample - 3/8 inch reduced diam., rotating beam - 2700 r.p.m. R = -1, samples at 13,400 psi - 10^8 cycles did not break.	99.91				0.03	0.04O, 0.01As	78
146a	Annealed 1112°F - 1 hr. - furnace cooled 392 to 482°F - water quenched, room temp.: U.T.S. = 31,200 psi - Brinell hardness = 47. Flexural cantilever, samples at 10,000 psi - 6×10^7 and 1.4×10^8 cycles did not break.	99.92		0.01			0.01Pb, 0.01Fe	146
146b	Flexural beam. Other specifications same as 146a.	99.92		0.01			0.01Pb, 0.01Fe	146
204a	Annealed 250°F - 3 hrs. - after cold working, room temp.: U.T.S. = 46,500 psi - Y.S. = 21,200 psi (0.01% offset), bar supplied - 1 inch diam. Sample - conically tapered, rotating cantilever - 1450 r.p.m., tested in air.	99.996						204
204b	Tested in 33% salt water, includes 2 tests in fresh water. Other specifications same as 204a.	99.996						204
204c	Annealed 1200°F - 1 hr. - after hot rolling, room temp.: U.T.S. = 31,200 psi - Y.S. = 4,500 psi (0.01% offset). Other specifications same as 204a.	99.996						204
204d	Tested in 33% salt water, includes one test in fresh water. Other specifications same as 204a.	99.996						204
261	Annealed 932°F - 1 hr. - in vacuum - furnace cooled, room temp.: U.T.S. = 31,000 psi - Y.S. = 2,500 psi (0.1% offset) - Vickers hardness = 45. Bar sample - 0.16 inch reduced diam., single point rotating cantilever - 4500 r.p.m.							261
386a	Annealed 600°C - 1/2 hr., room temp.: U.T.S. = 33,400 psi - Y.S. = 6,850 psi (0.2% offset) - R_F = 34.0. Rotating beam.	99.93						386
436b	Annealed, room temp.: U.T.S. = 32,100 psi - Y.S. = 3,700 psi. Rotating cantilever.						0.01Fe	436
456a	Annealed 250°F - 3 hrs. - furnace cooled, room temp.: U.T.S. = 46,900 psi - Y.S. = 20,000 psi. Notched sample - 0.5 inch diam. at circumferential notch - 0.0055 inch notch radius (K_T = 6.72), rotating cantilever - 1450 r.p.m., R = -1.						0.01Fe	456
456b	Annealed 750°F - 2 hrs. - furnace cooled, room temp.: U.T.S. = 30,300 psi - Y.S. = 4,700 psi. Other specifications same as 456a.						0.01Fe	456

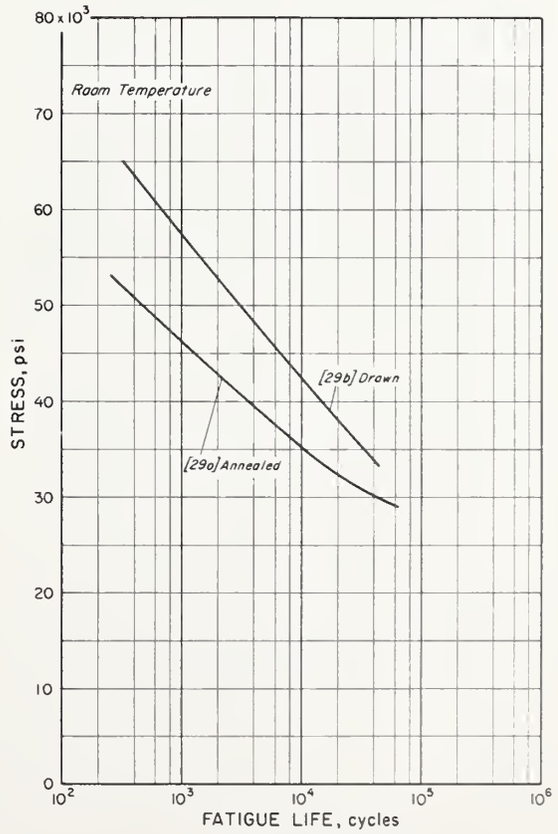


Fatigue Behavior of Copper (Oxygen-Free High-Conductivity)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
192a	Annealed.							192
289	Annealed 1022°F - 1 hr. - after machining sample. 1800c.p.m. samples at 25,000 psi - 1.5×10^5 cycles and 10,000 psi - 4×10^7 cycles did not break.							289
343a	Annealed - then electropolished in phosphoric acid, bar supplied - 1/4 inch diam. Bar sample - reduced section - 1-1/4 inches long × 7/32 inch diam., axial tension applied to sample undergoing alternating torsion at 1500c.p.m., torsion amplitude = 1.5°, tension stress plotted.							343
343b	Torsion amplitude = 2.0°. Other specifications same as 343a.							343
343c	Torsion amplitude = 2.5°. Other specifications same as 343a.							343
343d	Torsion amplitude = 3.0°. Other specifications same as 343a.							343

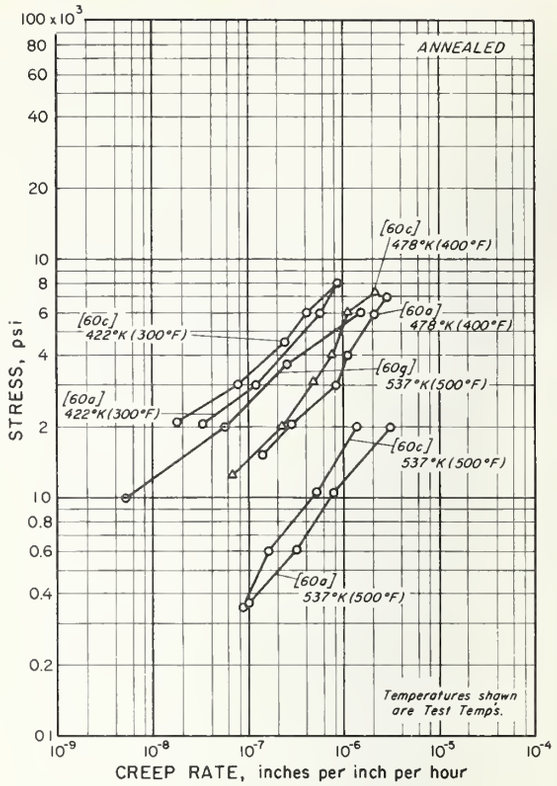


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
29a	Annealed 1112°F - 1/2 hr. - N_2 atmos., room temp.: U.T.S. = 30,000 psi - Y.S. = 2,700 psi (0.1% offset). Bar sample - 0.564 inch reduced diam., uniaxial stress - 10 c.p.m., R = -1, strain rate ≈ 5 inches/inch/minute.							29
29b	Drawn, room temp.: U.T.S. = 33,400 psi - Y.S. = 30,900 psi (0.1% offset). Other specifications same as 29a.							29

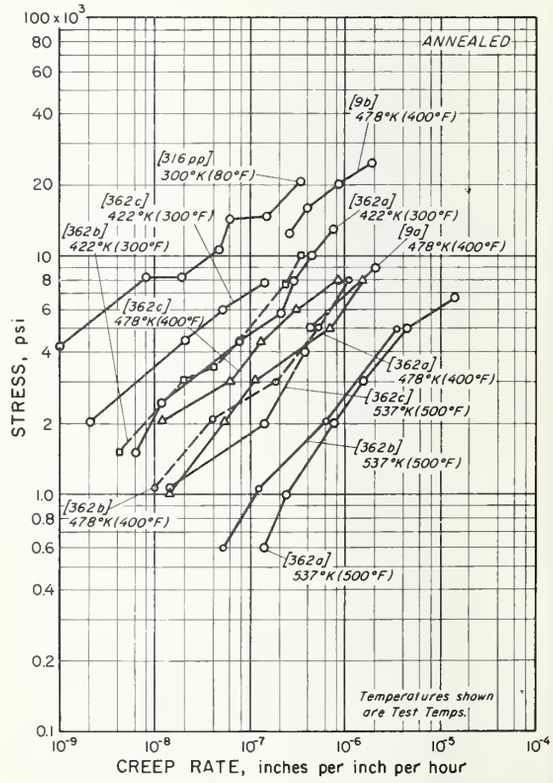


Creep Behavior of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
60a	Annealed - 0.025mm. G.S., room temp.: U.T.S. = 35,100 psi - Y.S. = 7,200 psi (0.5% strain), electrolytic tough pitch. Bar sample - 1/8 inch diam.	99.96						60
60c	Annealed - 0.025mm. G.S., room temp.: U.T.S. = 34,500 psi - Y.S. = 7,900 psi (0.5% strain), oxygen-free high-conductivity. Bar sample - 1/8 inch diam.	99.98	0.01					60
60g	Annealed - 0.045mm. G.S., room temp.: U.T.S. = 35,000 psi - Y.S. = 6,100 psi (0.5% strain). Bar sample - 1/8 inch diam.	99.60	0.01			0.01	0.32As, 0.02P, 0.02Fe	60

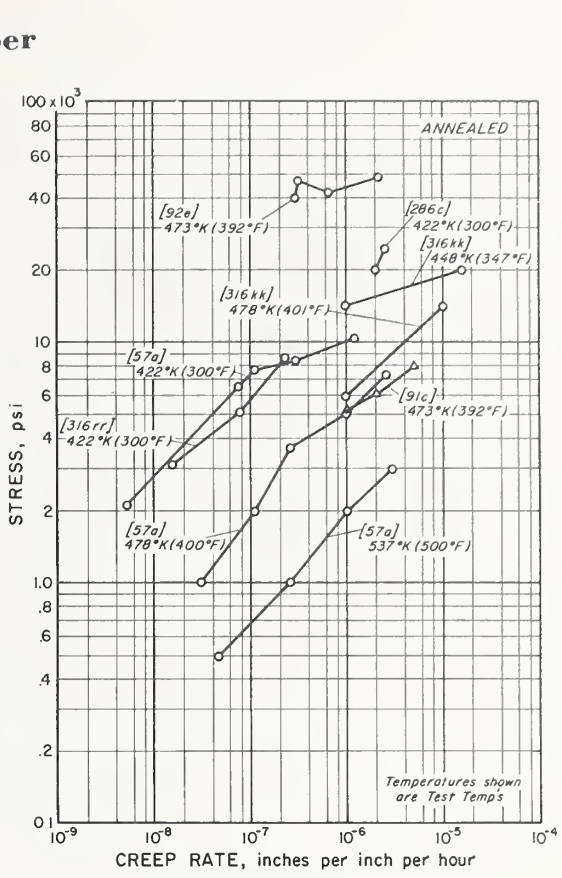


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
9a	"Fully annealed": electrolytic tough pitch. Total test time = 1000 hrs.							9
9b	Annealed - R_B = 34, phosphorized, bar supplied - 3/4 inch diam., total test time = 1000 hrs.	99.97					0.02P	9
316pp	Annealed - 0.040mm. G.S., electrolytic tough pitch, wire supplied - 0.040 inch diam. Second stage creep.	99.93						316
362a	Annealed - 0.015mm. G.S., phosphorized, bar supplied - 3 inch diam. Bar sample - 1/8 inch diam. - 10 inch G.L., second stage creep.	99.98					0.02P	362
362b	Annealed - 0.032mm. G.S., phosphorized, bar supplied - 3 inch diam. Bar sample - 1/8 inch diam. - 10 inch G.L., second stage creep.	99.93					0.02P	362
362c	Annealed - 0.070mm. G.S., phosphorized, bar supplied - 3 inch diam. Bar sample - 1/8 inch diam. - 10 inch G.L., second stage creep.	99.93					0.02P	362

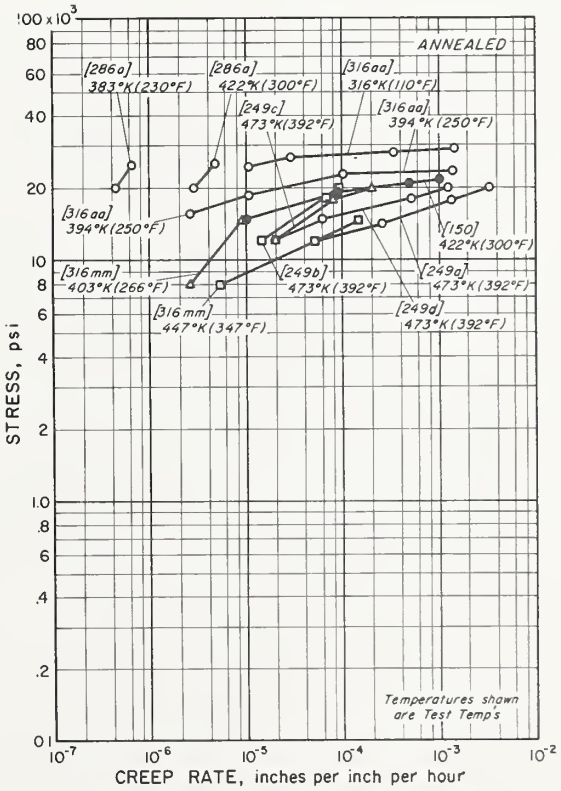


Creep Behavior of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
57a	Annealed - 0.013mm. G.S., room temp.: U.T.S. = 36,500 psi - Y.S. = 12,000 psi (0.5% strain), phosphorized Bar sample - 0.125 inch diam., average test time ≈5500 hrs. Second stage creep.	99.95					0.01P	57
91c	Soft. Rate taken at 1000 hrs.	99.09		0.91				91
92e	Annealed 932°F - 2-1/2 hrs. - furnace cooled. Rate taken at 1000 hrs.	99.76					0.24Zr	92
286c	Annealed. Wire sample - 0.081 inch diam., second stage creep.	99.94					0.05Ag	286
316kk	Annealed - 0.030mm. G.S. - R_F = 40, sheet supplied - 0.1 inch thick. Second stage creep.	99.89					0.03Ag, 0.02O	316
316rr	Annealed - 0.025mm. G.S., bar supplied - 0.125 inch diam. Second stage creep.	99.53					0.46Te, 0.01P	316

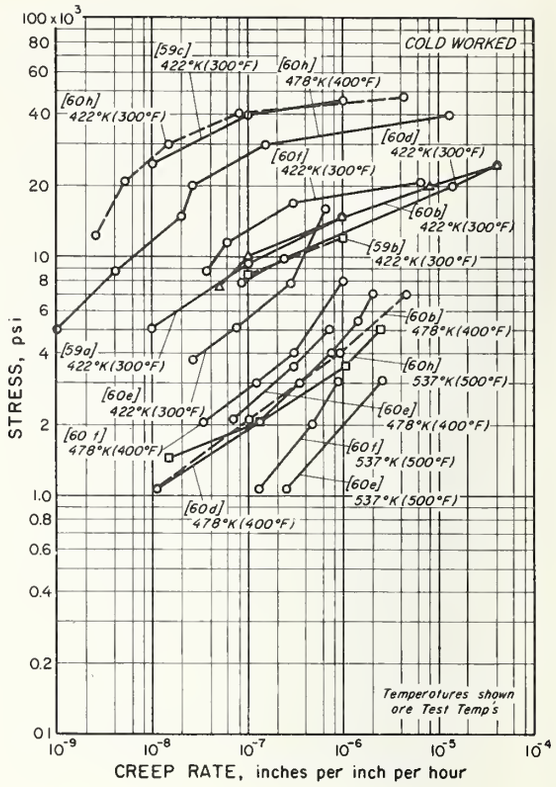


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
150	Annealed - 0.025mm. G.S., oxygen-free high-conductivity. Bar sample - 0.505 inch diam. - 2 inches G.L. Second stage creep.	99.99						150
249a	Annealed 1562°F - 1 hr. - N_2 atmos. - furnace cooled at rate of 212°F/hr. - 0.0007mm. G.S., oxygen-free high-conductivity. Bar sample - 0.16 inch diam., 1 inch G.L. Second stage creep.	99.98						249
249b	Annealed 1562°F - 1 hr., N_2 atmos. - furnace cooled at rate of 212°F/hr. - 0.125mm. G.S., oxygen-free high-conductivity. Bar sample - 0.16 inch diam. - 1 inch G.L. Second stage creep.	99.98						249
249c	0.33mm. G.S. Bar sample - 0.375 inch diam. - 2.5 inches G.L. Other specifications same as 249b.	99.98						249
249d	0.0007mm. G.S. Bar sample - 0.505 inch diam., 2.5 inches G.L. Other specifications same as 249a.	99.98						249
286a	Annealed - room temp.: U.T.S. = 37,000 psi - Y.S. = 6,500 psi (0.2% offset), oxygen-free high-conductivity. Wire sample - 0.081 inch diam., 230°F: second stage creep 20,000 psi; first stage - 25,000 psi, 300°F: first stage - 25,500 psi.	99.99						286
316aa	Annealed - 0.025mm. G.S. - R_F = 34, oxygen-free high-conductivity. Bar sample - 0.125 inch diam. Second stage creep.	99.99	0.01					316
316 mm	Annealed - 0.030mm. G.S. - R_F = 47, electrolytic tough pitch, sheet supplied - 0.1 inch thick. Second stage creep.	99.97					0.03O	316

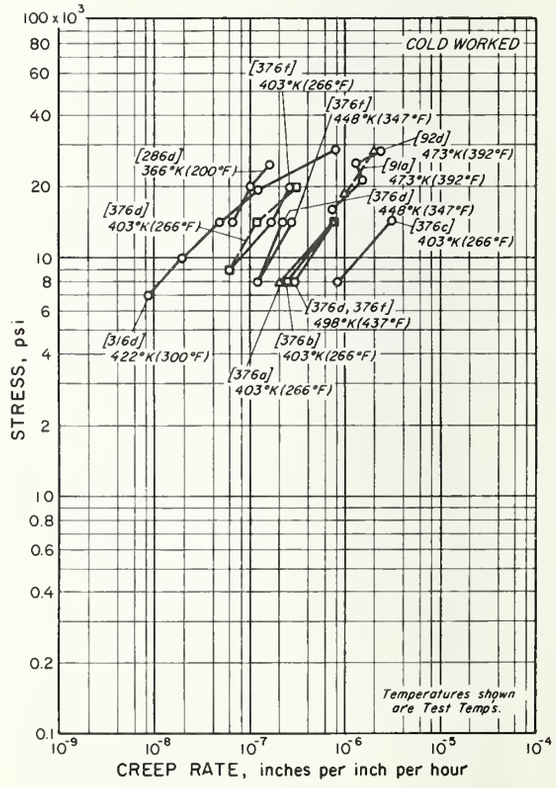


Creep Behavior of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
59a	Drawn 84%, room temp.: U. T. S. = 55,400 psi, electrolytic tough pitch. Bar sample - 1/4 inch diam.	99.96						59
59b	Drawn 84%, room temp.: U. T. S = 54,500 psi, oxygen-free high-conductivity. Bar sample - 1/4 inch diam.	99.93						59
59c	Drawn 84%, room temp.: U. T. S = 60,900 psi. Bar sample - 1/4 inch diam.	99.60					0.32As	59
60a	Drawn 84%, room temp.: U. T. S. = 55,400 psi - Y. S. = 50,000 psi (0.5% strain), electrolytic tough pitch. Bar sample - 1/8 inch diam., third stage creep at 14,650 - 20,000 - 25,200 psi.	99.96						60
60d	Drawn 84%, room temp.: U. T. S. = 54,500 psi - Y. S. = 49,500 psi (0.5% strain), oxygen-free high-conductivity. Bar sample - 1/8 inch diam., third stage creep at 9,950 - 20,000 - 25,100 psi.	99.98	0.01					60
60e	Drawn 1% - after annealing - 0.013mm. G.S., room temp.: U. T. S = 37,000 psi - Y. S. = 15,400 psi (0.5% strain), phosphorized. Bar sample - 1/8 inch diam.	99.93						60
60f	Drawn 6% - after annealing - 0.013mm. G.S., room temp.: U. T. S. = 41,300 psi - Y. S = 33,000 psi (0.5% strain), phosphorized Bar sample - 1/8 inch diam.	99.95						60
60h	Drawn 84%, room temp.: U. T. S = 60,900 psi - Y. S. = 55,500 psi (0.5% strain). Bar sample - 1/8 inch diam.	99.60	0.01			0.01	0.32As, 0.02P, 0.02Fe	60

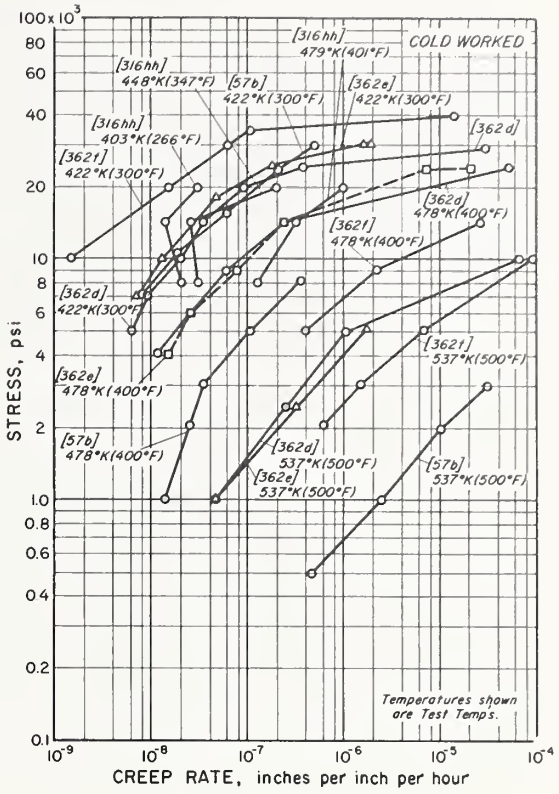


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
91a	Hard. Rate taken at 1000 hrs.	99.07		0.91				91
92d	Hard. Rate taken at 1000 hrs.	99.24					0.76Cr	92
286d	Cold drawn 84.4% - after annealing, room temp.: U. T. S. = 65,200 psi - Y. S. = 65,000 psi (0.2% offset), electrolytic tough pitch, Wire sample - 0.081 inch diam. Second stage creep.	99.96					0.03O	286
316d	Drawn 37%, bar supplied - 0.125 inch diam. Second stage creep.	99.5%					0.46Te, 0.01P	316
376a	Cold worked 10% - 0.035mm. G.S. - Vickers hardness = 91.1 (20 kgm. load), electrolytic tough pitch, strip supplied - 1-1/4 X 0.1 inch cross section. Strip sample - 1/2 X 0.1 inch cross section - 5 inch G.L. Second stage creep.	99.97					0.03O	376
376b	Cold worked 25% - 0.030mm. G.S. - Vickers hardness = 103.0 (20 kgm. load), electrolytic tough pitch. Other specifications same as 376a.	99.97					0.03O	376
376c	Cold worked 50% - Vickers hardness = 114.5 (20 kgm. load) electrolytic tough pitch. Other specifications same as 376a.	99.97					0.03O	376
376d	Cold worked 10% - 0.030mm. G.S. - Vickers hardness = 96.1 (20 kgm. load). Other specifications same as 376a.	99.89					0.09Ag, 0.02O	376
376f	Cold worked 50% - Vickers hardness = 116.0 (20 kgm. load). Other specifications same as 376a.	99.89					0.09Ag, 0.02O	376



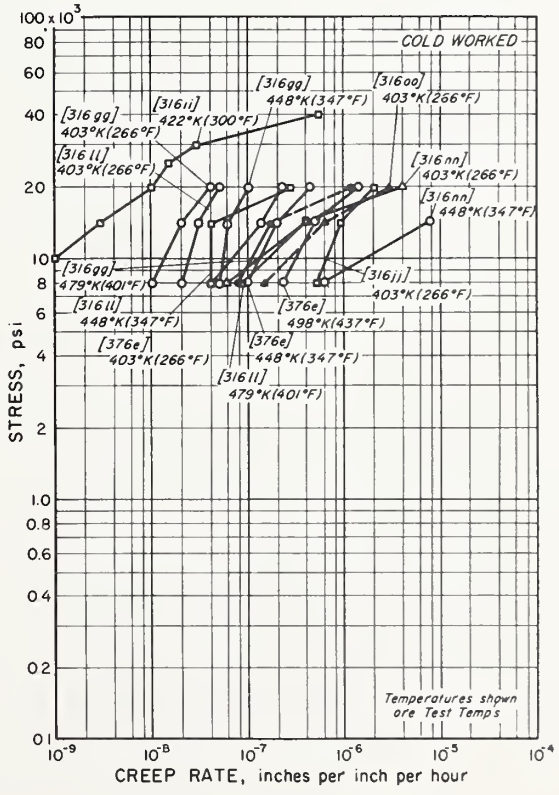
Creep Behavior of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
57b	Drawn 84%; room temp.: U.T.S. = 57,500 psi - Y.S. = 53,000 psi (0.2% offset), phosphorized. Bar sample - 0.125 inch diam., average test time ≈5500 hrs. Second stage creep.	99.95					0.01P	57
316hh	Cold rolled 50% - R_B = 65, sheet supplied - 0.1 inch thick. Second stage creep.	99.89					0.09Ag, 0.02O	316
362d	Drawn 21%, phosphorized, bar supplied - 3 inch diam. Bar sample - 1/8 inch diam. - 10 inch G.L., 300°F - second stage creep except for 29,900 psi: third stage; 400°F - second stage except for 25,000 psi: third stage; 500°F second stage except for 10,000 psi: third stage.	99.98					0.02P	362
362e	Drawn 37%, phosphorized, bar supplied - 3 inch diam. Bar sample - 1/8 inch diam. - 10 inch G.L. 300°F - second stage except for 30,100 psi: third stage; 400°F - second stage except for 25,150 psi: third stage; 500°F - second stage.	99.93					0.02P	362
362f	Drawn 84%, phosphorized, bar supplied - 3 inch diam. Bar sample - 1/8 inch diam. - 10 inch G.L., 300°F - second stage except for 39,950 psi: third stage; 400°F - second stage except for 5,050 - 9,050 - 15,000 psi: third stage; 500°F - second stage except for 10,000 psi: third stage.	99.98					0.02P	362



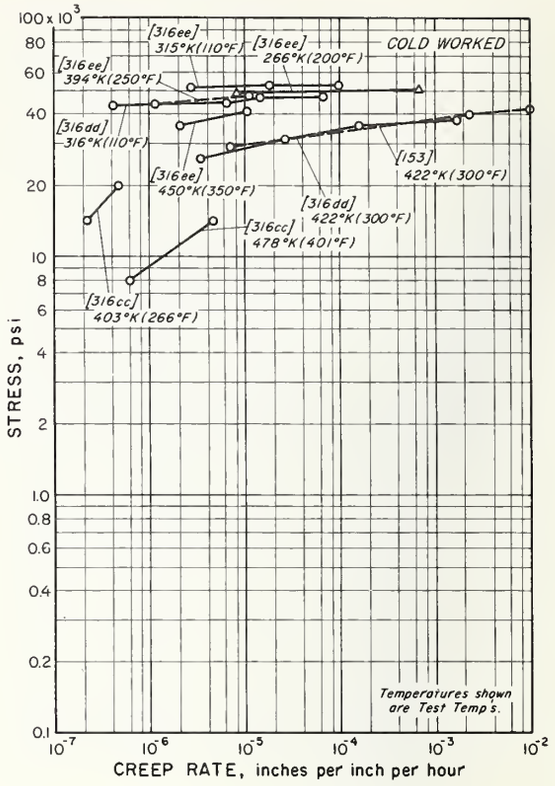
Creep Behavior of Copper (Electrolytic Tough Pitch)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
316gg	Cold rolled 25% - 0.035mm. G.S. - R_B = 53, sheet supplied - 0.1 inch thick. Second stage creep.	99.89					0.09Ag, 0.02O	316
316ii	Drawn 84%, bar supplied - 0.125 inch diam. Second stage creep.	99.95	0.01				0.03Ag	316
316jj	Cold rolled 50% - R_B = 64, electrolytic tough pitch, sheet supplied - 0.1 inch thick. Second stage creep.	99.97					0.03O	316
316ll	Cold rolled 10% - 0.030mm. G.S. - R_B = 51, sheet supplied - 0.1 inch thick. Second stage creep.	99.90					0.03Ag, 0.02O	316
316nn	Cold rolled 10% - 0.035mm. G.S - R_B = 50, electrolytic tough pitch, sheet supplied - 0.1 inch thick. Second stage creep.	99.97					0.03O	316
316oo	Cold rolled 25% - 0.030mm. G.S. - R_B = 59, electrolytic tough pitch, sheet supplied - 0.1 inch thick. Second stage creep.	99.97					0.03O	316
376e	Cold worked 25% - 0.035mm. G.S. - Vickers hardness = 105.0 (20 kgm. load), strip supplied - 1-1/4 X 0.1 inch cross section. Strip sample - 1/2 X 0.1 inch cross section - 5 inch G.L. Second stage creep.	99.89					0.09Ag, 0.02O	376

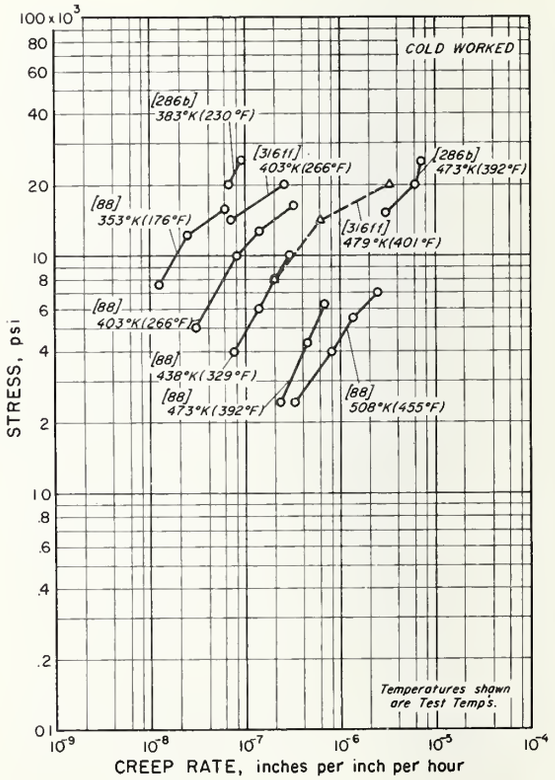


Creep Behavior of Copper (Oxygen-Free High-Conductivity)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
153	Drawn 40%. Bar sample - reduced section - 2 inches long X 0.505 inch diam. Second stage creep.	99.99						153
316cc	Cold rolled 25% - 0.03mm. G.S. - R_B = 56. Sheet supplied - 0.1 inch thick. Second stage creep.	99.995						316
316dd	Cold drawn 40% - 0.025mm. G.S. - R_F = 86. Second stage creep.	99.99						316
316ee	Cold drawn 75% - approx. 0.12mm. G.S. Second stage creep.	99.97						316

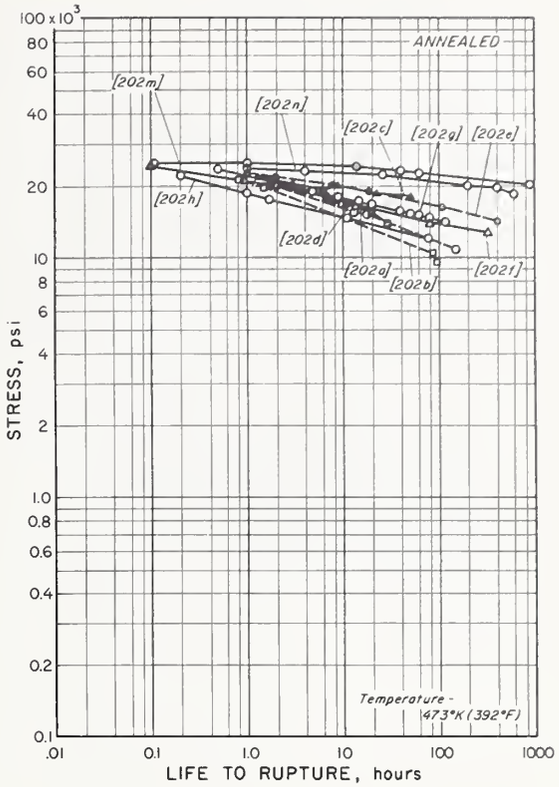


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
88	Drawn 8%. Bar sample - 0.2 inch diam., 20 inch G.L.							88
286b	Cold drawn 84.4% - after annealing, room temp.: U.T.S. = 66,300 psi - Y.S. = 66,000 psi (0.2% offset). Wire sample - 0.081 inch diam., 230°F - second stage creep; 300°F - third stage.	99.99						286
316ff	Cold rolled 25% - 0.035mm. G.S. - R_B = 56, sheet supplied - 0.1 inch thick. Second stage creep.	99.92					0.07Ag	316

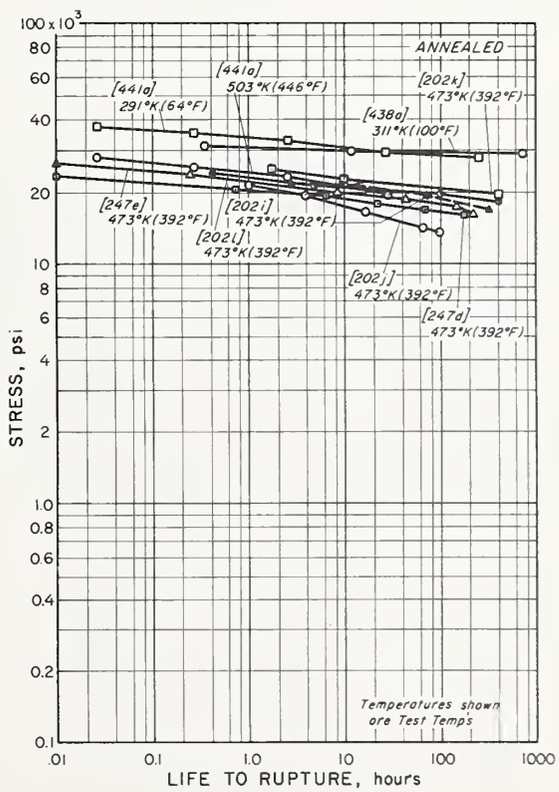


Stress-Rupture Behavior of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
202a	Annealed 1562°F, N_2 atmos. - 1 hr. - furnace cooled, bar supplied - 0.25 inch diam. Bar sample - 0.159 inch diam., load constant.	99.995						202
202b	Water quenched. Other specifications same as 202a.	99.995						202
202c	Annealed 1562°F in vacuum - 1 hr. - furnace cooled, bar supplied - 0.25 inch diam. Bar sample - 0.159 inch diam., load constant.	99.99						202
202d	Water quenched. Other specifications same as 202c.	99.99						202
202e	Annealed 1562°F, N_2 atmos. - 1 hr., furnace cooled, electrolytic tough pitch, bar supplied - 0.25 inch diam. Bar sample - 0.159 inch diam., load constant.	99.96					0.04O	202
202f	Water quenched. Other specifications same as 202a.	99.96					0.04O	202
202g	Annealed 1562°F in vacuum - 1 hr. - furnace cooled, bar supplied - 0.25 inch diam. Bar sample - 0.159 inch diam., load constant.	99.999						202
202h	Water quenched. Other specifications same as 202g.	99.999						202
202m	Same specifications as 202e.	99.92					0.04O, 0.03Ag	202
202n	Sample at 17,500 psi -600 hrs. did not break. Other specifications same as 202f.	99.92					0.04O, 0.03Ag	202

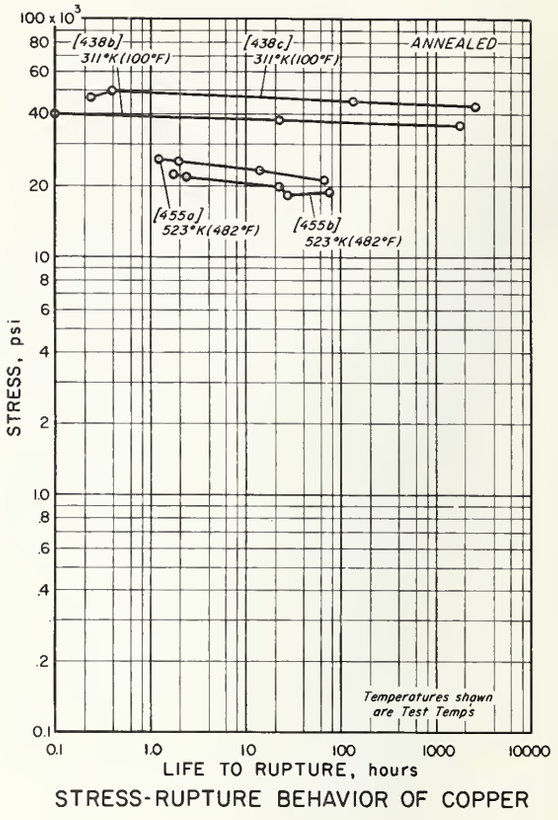


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
202i	Annealed 1562°F, N_2 atmos. - 1 hr. - furnace cooled, oxygen-free high-conductivity, bar supplied - 0.25 inch diam. Bar sample - 0.159 inch diam., load constant.	99.99						202
202j	Water quenched, oxygen-free high-conductivity. Other specifications same as 202i.	99.99						202
202k	Same specifications as 202i.	99.94					0.05Ag	202
202ℓ	Same specifications as 202j.	99.94					0.05Ag	202
247d	Annealed 932°F, electrolytic tough pitch. Wire sample - 0.116 inch diam.							247
247e	Annealed 572°F, electrolytic tough pitch. Wire sample - 0.110 inch diam.							247
438a	Annealed 932°F - 1 hr. and pickled - 0.028mm. G.S., Vickers hardness = 52.7, 100°F: U.T.S. = 33,200 psi - Y.S. = 10,500 psi (0.1% offset), electrolytic tough pitch, strip supplied. Strip sample - 0.064 inch thick - cut normal to rolling direction.	99.96					0.02O, 0.01Pb, 0.01Sn	438
441a	Annealed 932°F - 1 hr. - room temp.: U.T.S. = 32,800 psi. Tested in torsion, constant shear stress, no tensile stress.	99.9						441



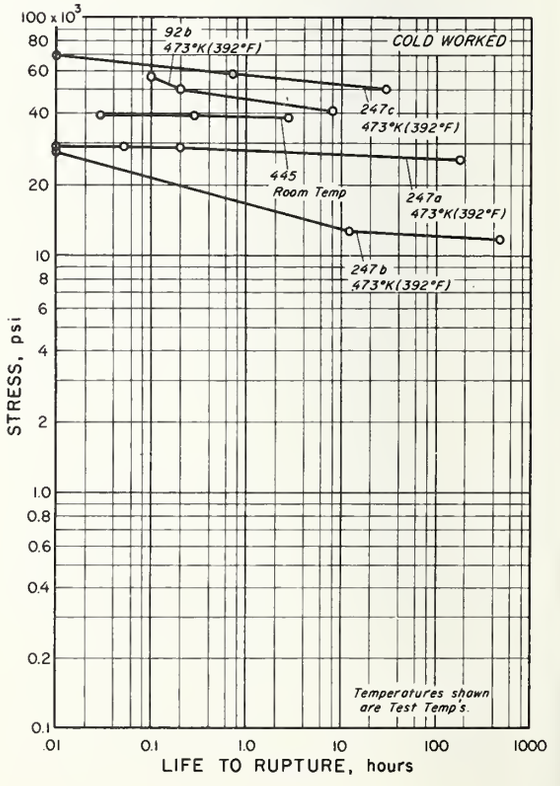
Stress-Rupture Behavior of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
438b	Half hard - 0.025mm. G.S. - Vickers hardness = 94.8, 100°F: U.T.S. = 41,900 psi, Y.S. = 36,200 psi (0.1% offset), electrolytic tough pitch, strip supplied. Strip sample - 0.064 inch thick - cut normal to rolling direction.	99.96					0.02O, 0.01Pb, 0.01Sn	438
438c	Hard - 0.014mm. G.S., Vickers hardness = 111, 100°F: U.T.S. = 52,900 psi, Y.S. = 43,900 psi (0.1% offset), electrolytic tough pitch, strip supplied. Strip sample - 0.064 inch thick - cut normal to rolling direction.	99.96					0.02O, 0.01Pb, 0.01Sn	438
455a	Annealed 1562°F - H_2 atmos. - 1 hr. - furnace cooled 194°F/hr., bar supplied - 0.25 inch diam. Bar sample - 0.160 inch diam.						0.05Ag	455
455b	Water quenched. Other specifications same as 455a.						0.05Ag	455



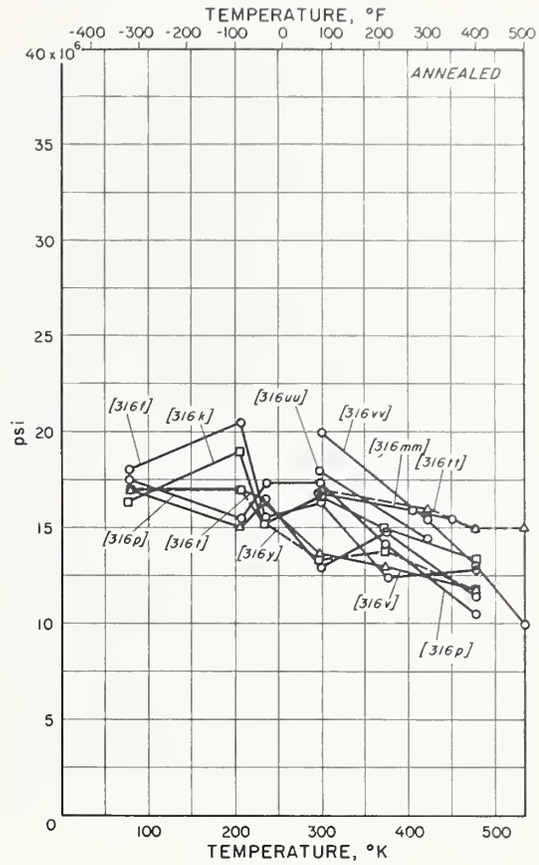
STRESS-RUPTURE BEHAVIOR OF COPPER

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
92b	Hard.							92
247a	Wire sample - 0.091 inch diam. Samples at 22,000 psi - 190 hrs. and 21,000 psi - 680 hrs. did not break.	99.8					0.2Cd	247
247b	Strip sample - 0.260 X 0.050 inch thick. Sample at 20,000 psi - 500 hrs. did not break.	99.9					0.1Mn	247
247c	Cold drawn 60.6% - after first annealing 1832°F - then cold drawing 56.1% - then aging 842°F - 3 hrs. Wire sample - 0.064 inch diam., samples at 47,000 psi - 520 hrs. and 42,000 psi - 620 hrs. did not break.	99.01					0.9Cr, 0.09Si	247
445	Sintered 1904°F - 20 hrs							445

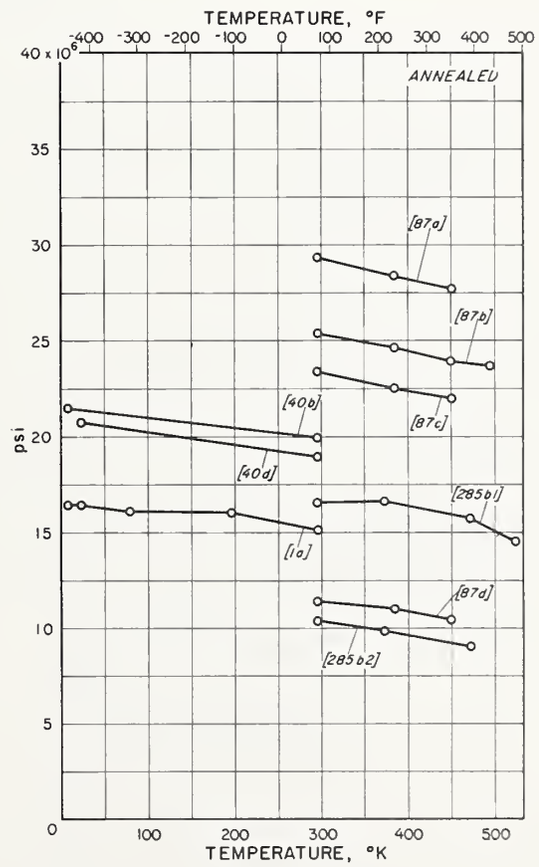


Modulus of Elasticity of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
316f	Annealed 1150°F - 1/2 hr. - 0.040mm. G.S. - after hot rolling, electrolytic tough pitch. Sheet sample - 1/2 inch wide X 1/8 inch thick, tested parallel to rolling direction.	99.90						316
316k	Annealed 1150°F - 1/2 hr. - 0.045mm. G.S. - after hot rolling, oxygen-free high conductivity. Sheet sample - 1/2 inch wide X 1/8 inch thick, tested parallel to rolling direction.	99.96						316
316p	Annealed 1150°F - 1/2 hr. - 0.045mm. G.S. - after hot rolling, phosphorized. Sheet sample - 1/8 inch thick X 1/2 inch wide, tested parallel to rolling direction.	99.90					0.02 - 0.04P	316
316t	Electrolytic tough pitch. Tested transverse to rolling direction. Other specifications same as 316f.	99.90						316
316v	Oxygen-free high-conductivity. Tested transverse to rolling direction. Other specifications same as 316k.	99.96						316
316y	Phosphorized. Tested transverse to rolling direction. Other specifications same as 316p.	99.90					0.02 - 0.04P	316
316 mm	Annealed - 0.03mm. G.S. - R_F = 47, electrolytic tough pitch, sheet supplied - 0.1 inch thick.	99.97					0.03O	316
316tt	Annealed - 0.015mm. G.S., phosphorized. Bar sample - 0.125 inch diam.	99.98					0.02P	316
316uu	Annealed - 0.032mm. G.S., phosphorized. Bar sample - 0.125 inch diam.	99.93					0.02P	316
316vv	Annealed - 0.070mm. G.S., phosphorized. Bar sample - 0.125 inch diam.	99.98					0.02P	316

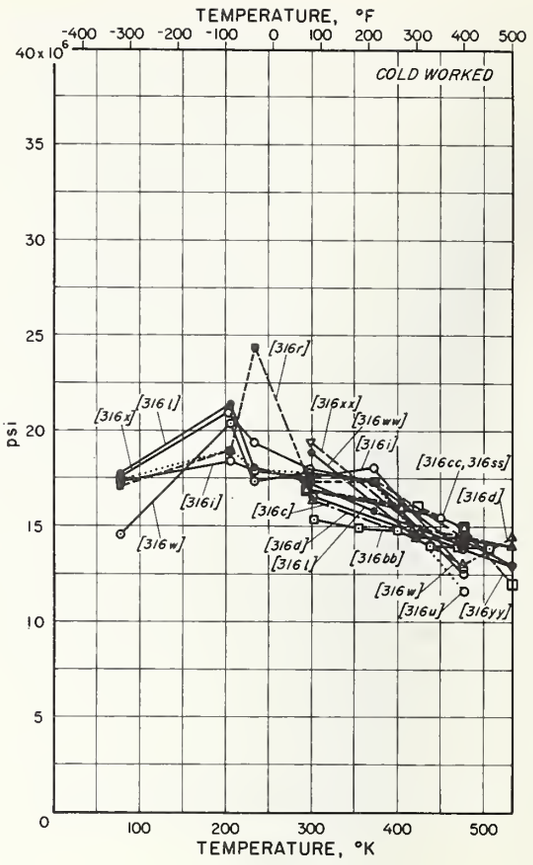


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1100°F - 1 hr. - 0.036mm. G.S. - R_F = 35, phosphorized, bar supplied - 3/4 inch diam. Bar sample - 0.250 inch diam., determined using clamp-on, strain gage extensometer - 1 inch G.L., crosshead speed = 0.02 inch/minute, data spread = ± 5%.	99.97					0.03P	1
40o	Annealed 347°F - 2 hrs. Bar sample - 2.52 inches long X 0.497 inch diam., dynamic measurement - longitudinal waves - approx. 30Kc. p.s.							40
40d	Annealed 302°F - 2 hrs., oxygen-free high-conductivity. Bar sample - 2.72 inches long X 0.497 inch diam., dynamic measurement - longitudinal waves - approx. 28Kc. p.s.							40
87a	Annealed (in measuring position), single crystal. Reed sample - 0.0394 inch thick X 0.354 inch wide X 1.97 to 5.91 inches long, grown by Bridgeman method, flexural vibrations - approx. 1000 c.p.s., orientation function - Γ = 0.327, $\Gamma \equiv (\cos\alpha_1 \cos\alpha_2)^2 + (\cos\alpha_2 \cos\alpha_3)^2 + (\cos\alpha_3 \cos\alpha_1)^2$ - α_1 - α_2 - α_3 are angles between sample axis and the 3 cubic edges.	99.999						87
87b	Γ = 0.284. Other specifications same as 87a.	99.999						87
87c	Γ = 0.260. Other specifications same as 87a.	99.999						87
87d	Γ = 0.044. Other specifications same as 87a.	99.999						87
285b1	Annealed 1202°F - 1/2 hr. Bar sample, static modulus.							285
285b2	Annealed 1202°F - 1/2 hr. Bar sample, dynamic modulus.							285

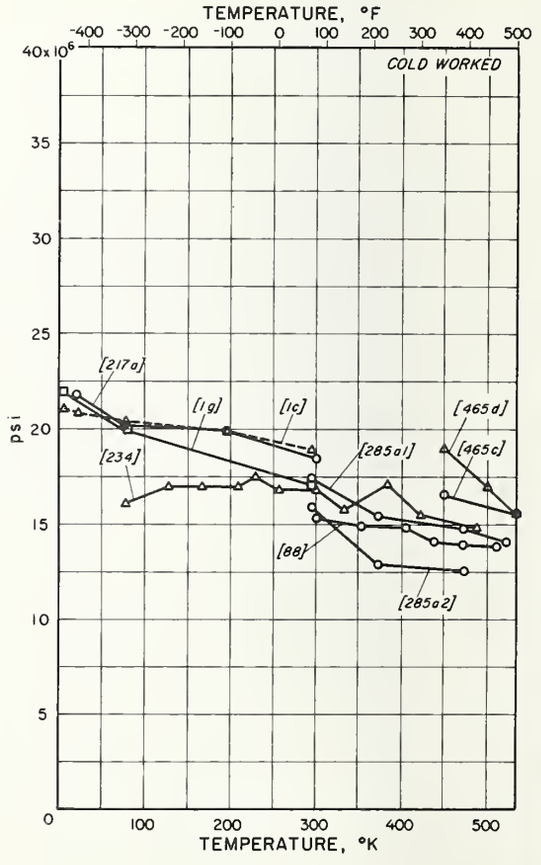


Modulus of Elasticity of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
316c	Cold drawn - R_B = 56, bar supplied - 3/4 inch diam.	99.64					0.35Te	316
316d	Drawn 37%, bar supplied - 0.125 inch diam.	99.53					0.46Te, 0.01P	316
316i	Cold rolled 5 to 7% - 0.042mm. G.S. - after hot rolling and annealing 1150°F - 1/2 hr., electrolytic tough pitch. Sheet sample - 1/2 inch wide X 1/8 inch thick, tested parallel to rolling direction.	99.90						316
316ℓ	Cold rolled 5 to 7% - 0.040mm. G.S. - after hot rolling and annealing 1150°F - 1/2 hr., oxygen-free high-conductivity. Sheet sample - 1/2 inch wide X 1/8 inch thick, tested parallel to rolling direction.	99.96						316
316r	Cold rolled 5 to 7% - 0.047mm. G.S. - after hot rolling and annealing 1150°F - 1/2 hr., phosphorized. Sheet sample - 1/8 inch thick X 1/2 inch wide, tested parallel to rolling direction.	99.90					0.02 - 0.04P	316
316u	Electrolytic tough pitch. Tested transverse to rolling direction. Other specifications same as 316i.	99.90						316
316w	Oxygen-free high-conductivity. Tested transverse to rolling direction. Other specifications same as 316ℓ.	99.96						316
316x	Phosphorized. Tested transverse to rolling direction. Other specifications same as 316r.	99.90					0.02 - 0.04P	316
316bb	Drawn 8% - after annealing, oxygen-free high-conductivity. Bar sample - 0.193 inch diam.							316
316cc	Cold rolled 25% - 0.035mm. G.S. - R_B = 56, oxygen-free high-conductivity, sheet supplied - 0.1 inch thick.	99.995						316
316ss	Cold rolled 10% - 0.040mm. G.S. - R_B = 49, sheet supplied - 0.1 inch thick.	99.92					0.07Ag	316
316 ww	Drawn 21%, phosphorized. Bar sample 0.125 inch diam.	99.98					0.02P	316
316xx	Drawn 37%, phosphorized. Bar sample - 0.125 inch diam.	99.98					0.02P	316
316yy	Drawn 84%, phosphorized. Bar sample - 0.125 inch diam.	99.98					0.02P	316

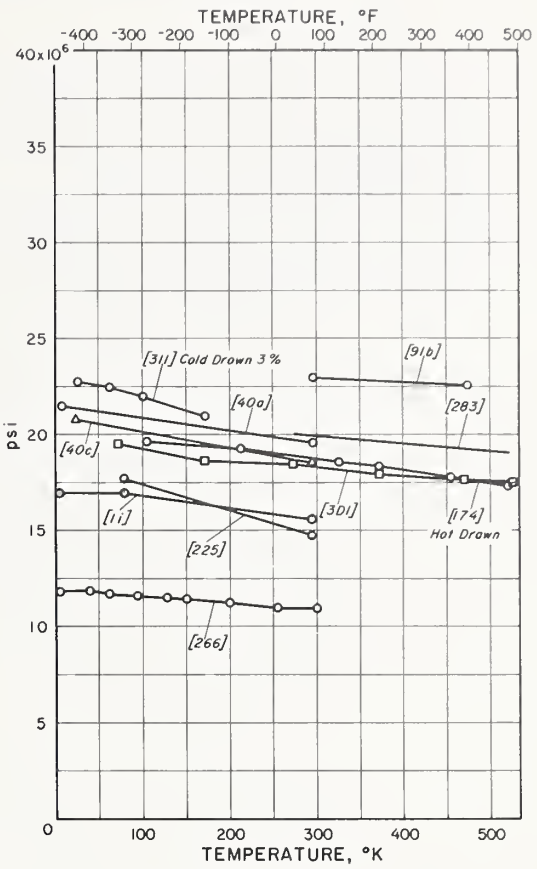


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
1c	Cold drawn 26% - 0.144mm. G.S. - R_B = 50, phosphorized, bar supplied - 3/4 inch diam. Bar sample - 0.250 inch diam, determined using clamp-on, strain gage extensometer - 1 inch G.L., crosshead speed = 0.02 inch/minute, data spread = ± 5%.	99.97					0.03P	1
1g	Cold drawn 60% - 0.287 to 2.00mm. G.S. - R_B = 45 to 53, oxygen-free high-conductivity. Other specifications same as 1c.	Bal		1ppm		4ppm	16ppm Ag, 12ppm S, 2ppm As, 5ppm Sb, <3ppm O	1
88	Drawn 8%, oxygen-free high-conductivity. Bar sample - 0.2 inch diam. - 20 inch G.L.							88
217	Drawn - R_B = 57, oxygen-free high-conductivity. Bar sample - 1/4 inch diam., values obtained from tensile stress vs. strain curves, strain rate ≈0.0005 inch/inch/minute to yield, 2 tests/temp.							217
234	Cold rolled 5 to 7%, phosphorized. Plate sample - 1/4 inch thick, cut parallel to rolling direction, 2 to 3 tests/temp.							234
285a1	Hard drawn. Bar sample, static modulus.							285
285a2	Hard drawn. Bar sample, dynamic modulus.							285
465c	Hard (original condition). Wire sample - 0.197 inch diam., sample strained to hard condition - then tested after 256 hrs., 1.97 inch G.L.							465
465d	Tested after 4 hrs. Other specifications same as 465c.							465



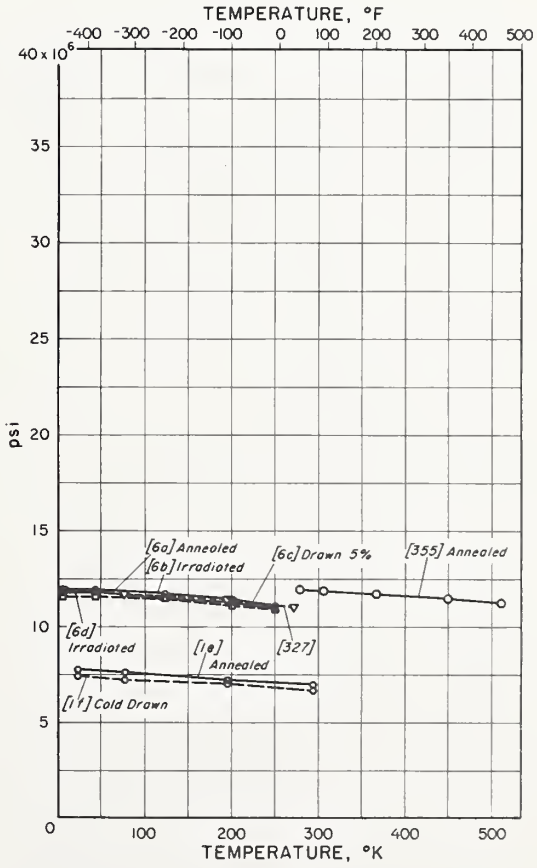
Modulus of Elasticity of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
1i	Aged 450°C - 1 hr. - 0.203mm. G.S. - R_B = 68 - after first heating to 950°C - water quenching - then cold drawing 85-90%, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.250 inch diam., crosshead speed = 0.02 inch/minute, 1 inch G.L., determined using clamp-on, strain gage extensometer.	Bal	Except for Zr, these elements are approximate.				0.18Zr, 16ppm Ag, 12ppm S, 2ppm As, 5ppm Sb, < 3ppm O	1
40a	Bar sample - 2.52 inches long X 0.497 inch diam., dynamic measurement - longitudinal waves - approx. 30Kc. p.s.							40
40c	Oxygen-free high-conductivity. Bar sample - 0.497 inch diam. X 2.72 inch long, dynamic measurement - longitudinal waves - approx. 28Kc. p.s.							40
91b		99.71					0.29Cr	91
174	Hot drawn 1472°F. Bar sample - approx. 7 inches long X 0.288 inch diam. transverse vibrations - nearest frequency = 765 c.p.s.							174
225		99.8						225
266	Single crystal - [110] orientation (within 1°). Ultrasonic pulse - 10Mc.p.s. Bar sample - 1 inch diam., 2 inches long.							266
283	Bulk modulus - calculated from thermal expansion data of Esser H., Eusterbrock H., Arch Eisenhüttenwes. 14, 341 (1941).							283
301	Oxygen-free high-conductivity. Plate sample - 4 inches long X 0.5 inch wide X approx. 0.05 inch thick, transverse vibrations - resonant frequency ≈ 1Kc.p.s. tested in vacuum of less than 0.0001mm., absolute error ≤ 1% - data reproducibility ≤ 0.1%.							301
311	Cold drawn 3.25% - after annealing 1202°F - 24 hrs., single crystal. Resonant bar technique - 10 to 20Kc.p.s.							311



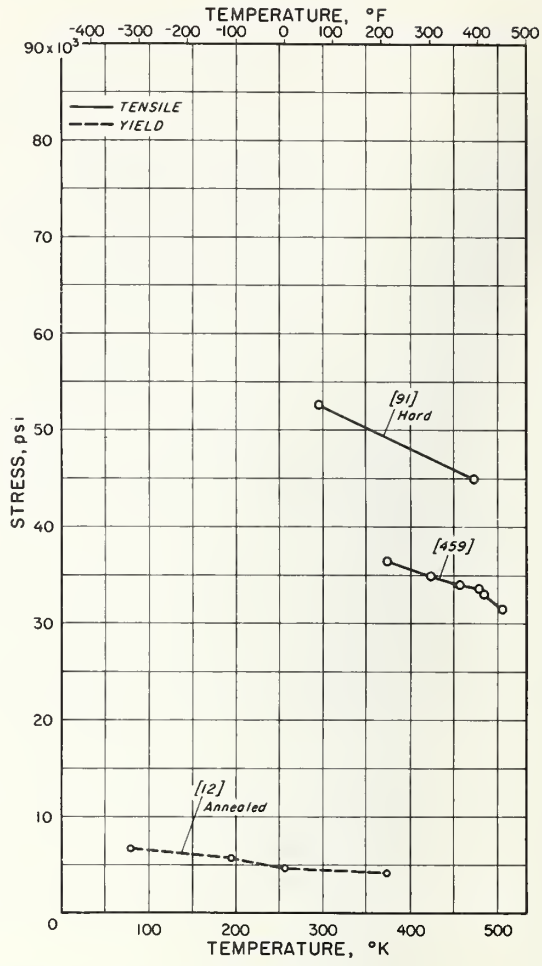
Modulus of Rigidity of Copper

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
1e	Annealed 1000°F - 1/2 hr. in vacuum - air cooled, phosphorized, bar supplied - 3/4 inch diam. Bar sample - 0.125 inch diam. - 2.5 inches long, shear modulus determined isothermally by applying weights, maximum shear stress of about 350 psi, data spread = ± 2%.	99.97					0.03P	1
1f	Cold drawn 4.3%, phosphorized. Other specifications same as 1e.	99.97					0.03P	1
6a	Annealed, single crystal. Ultrasonic pulse apparatus - 10Mc.p.s., variation of modulus ± 0.2%, measured shear constant C_{44}.	99.999						6
6b	Irradiated - after annealing. Other specifications same as 6a.	99.999						6
6c	Drawn 5%. Other specifications same as 6a.	99.999						6
6d	Irradiated - after drawing 5%. Other specifications same as 6a.	99.999						6
327	Single crystal - [110] orientation, oxygen-free high-conductivity. Pulse-like ultrasonic method - 10Mc.p.s., absolute error = ± 0.5%, measured shear constant C_{44}.	99.98						327
355	Annealed, single crystal - [001] orientation. Bar sample - 0.788 inch diam., ultrasonic pulse-echo technique - 10Mc. p.s., absolute error = ± 0.25%, measured the shear constant C_{44}.	99.99						355



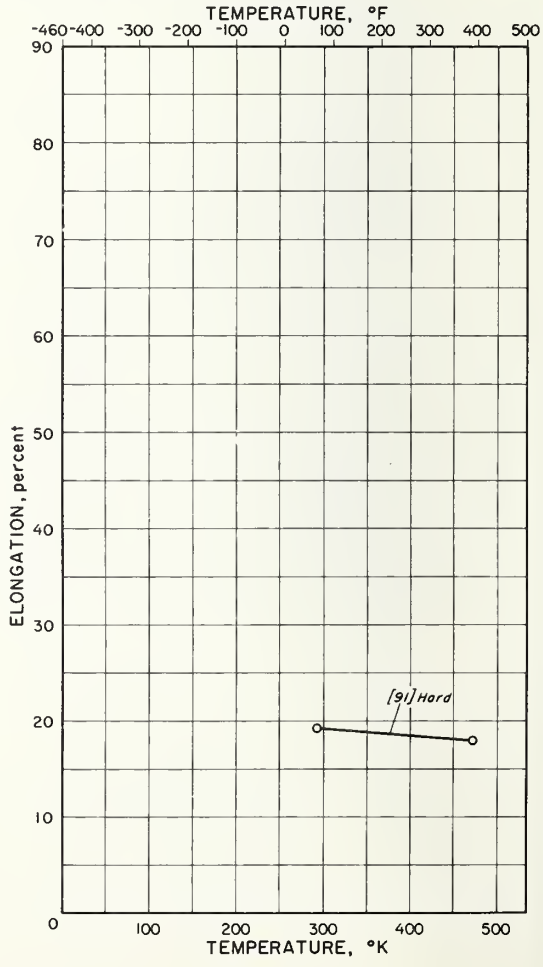
Tensile and Yield Strength of 95Cu-5Zn (Gliding Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
12	Annealed 752°F - 1 hr. - 0.027mm. G.S. Wire sample - 0.039 inch diam., strain rate = 0.001 inches/inch/minute, Y.S. - 0.01% offset.	96	4					12
91	Hard.	93.15	6.85					91
459	Wire sample, constant load applied while wire was heated at 36°F per minute until sample broke.	94.2	5.8					459



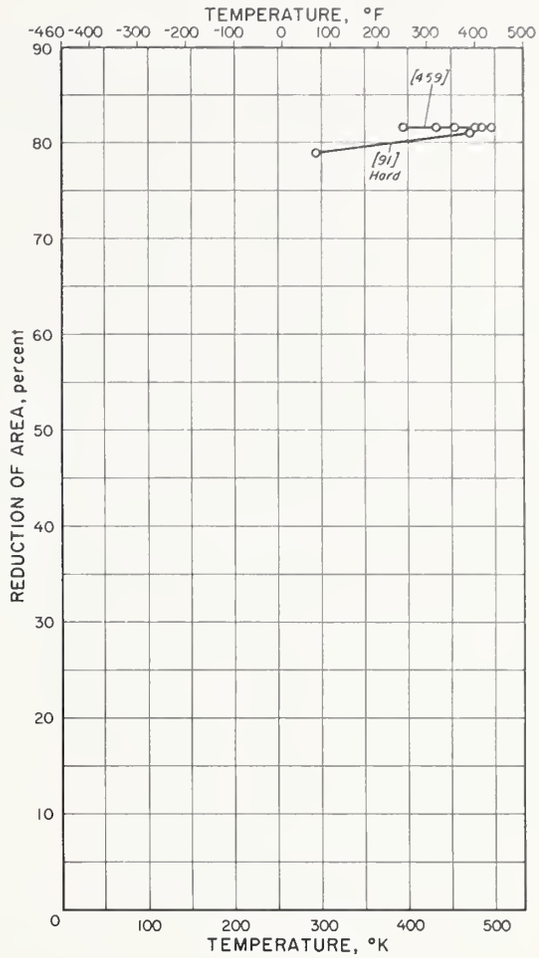
Tensile Elongation of 95Cu-5Zn (Gliding Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
91	Hard. 1.97 inch G.L.	93.15	6.85					91



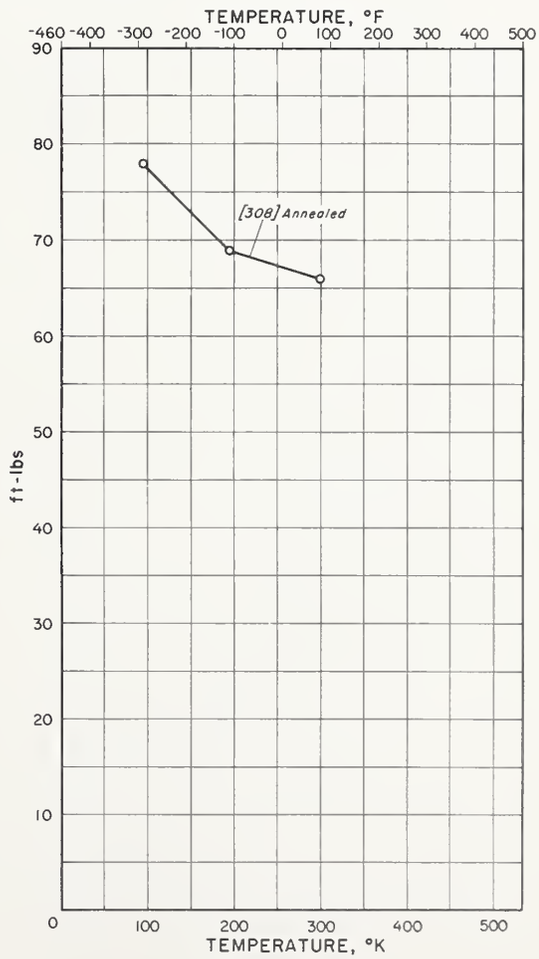
Tensile Reduction of Area of 95Cu-5Zn (Gliding Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
91	Hard.	93.2	6.8					91
459	Wire sample, constant load applied while wire was heated at 36°F/minute until sample broke.	94.2	5.8					459



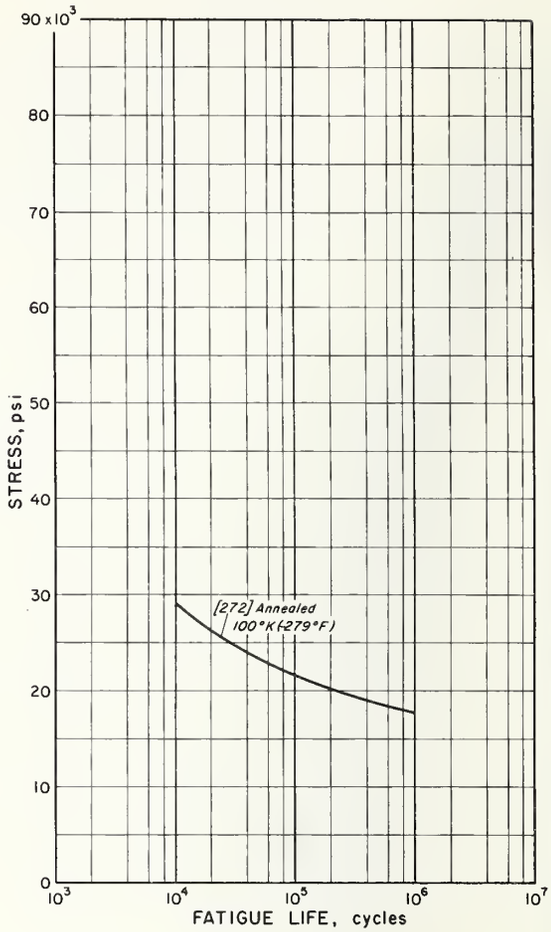
Impact Energy of 95Cu-5Zn (Gliding Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
308	Annealed. Izod.	96.8	3.0				0.1Fe	308



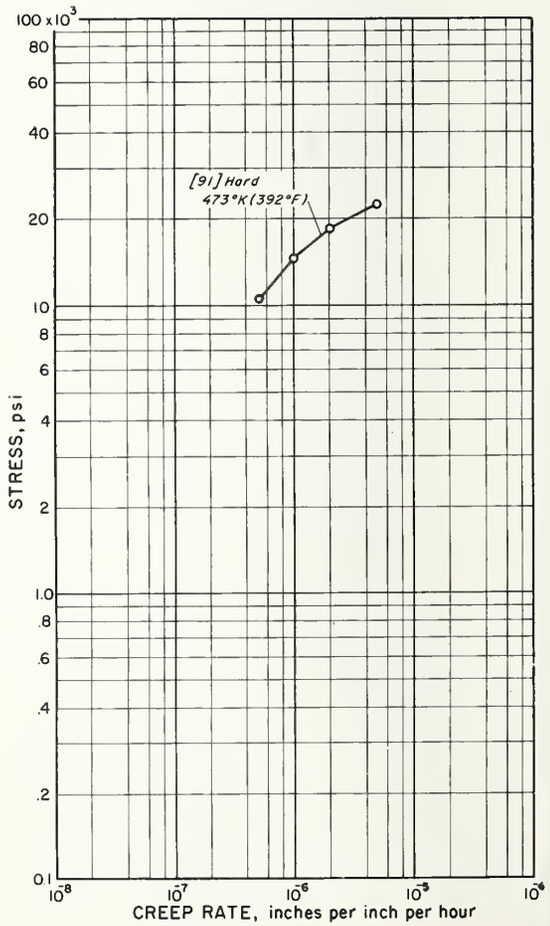
Fatigue Behavior of 95Cu-5Zn (Gliding Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
272	Annealed 932°F - Ar atmos - 1 hr. - 0.023mm. G.S. Bar sample - electropolished, 3600 r.p.m., R = -1.	93.4	6.6					272



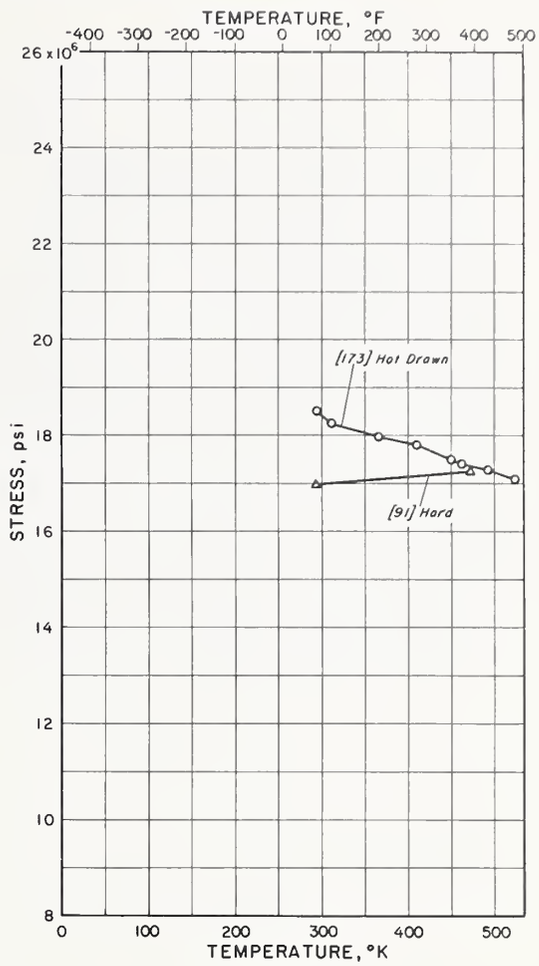
Creep Behavior of 95Cu-5Zn (Gliding Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
91	Hard. Rate taken at 1000 hrs.	93.2	6.8					91



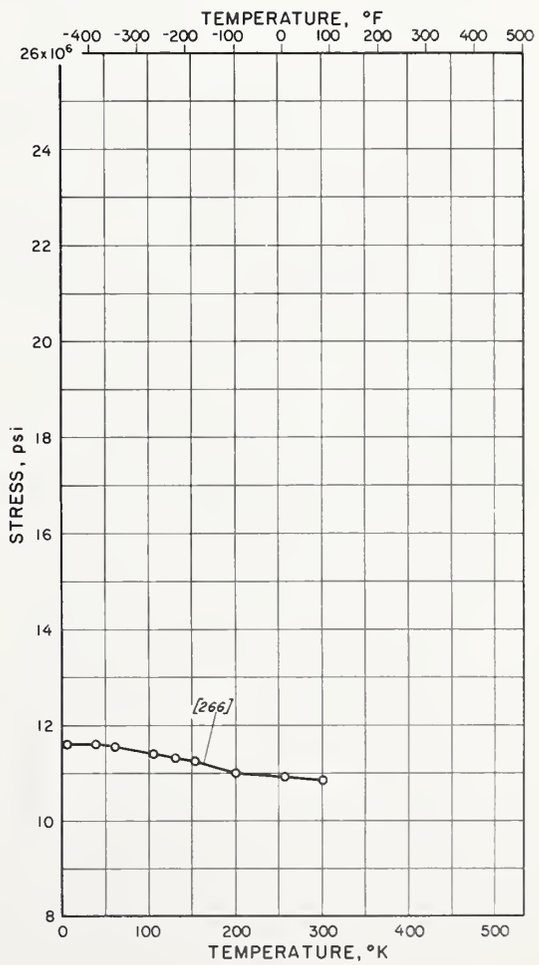
Modulus of Elasticity of 95Cu-5Zn (Gliding Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
91	Hard.	93.15	6.85					91
173	Hot drawn. Bar sample - 0.288 inch diam., transverse vibrations.	95	5					173



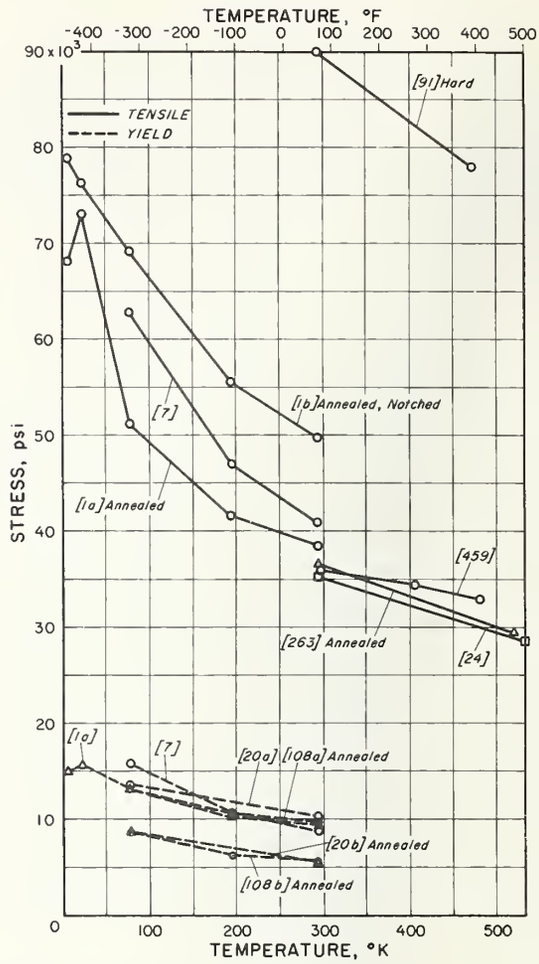
Modulus of Rigidity of 95Cu-5Zn (Gliding Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
266	Single crystal - [110] orientation (within 1°). Bar sample - 5/8 inch diam. × 5/8 inch long, ultrasonic pulse - 10 Mc.p.s., measured shear constant C_{44}.	95.8	4.2					266



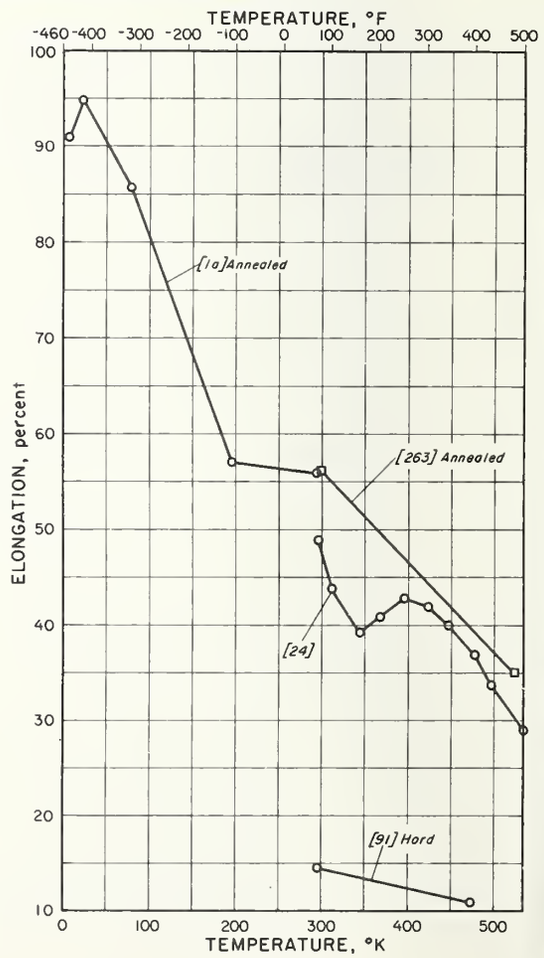
Tensile and Yield Strength of 90Cu-10Zn (Commercial Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1067°F - 3 hrs. - 0.051mm. G.S. - R_F = 49, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, Y.S. - 0.2% offset.	90.0	10.0					1
1b	Notched sample - 0.25 inch diam. at circumferential notch, 0.005 ± 0.0005 inch notch radius (K_T = 5.0). Other specifications same as 1a.	90.0	10.0					1
7								7
20a	Annealed - 0.016mm. G.S. - after hot reducing 75% - then cold rolling 40%. Bar sample - 1/4 inch diam., strain rate = 0.0028 inches/inch/minute.	89.2	10.8					20
20b	0.113mm. G.S. Other specifications same as 20a.	89.2	10.8					20
24	Wrought.	90	10					24
91	Hard.	89.6	10	0.4				91
108a	Annealed 1112°F in vacuum - air cooled - 0.03mm. G.S. Bar sample - 0.0788 inch diam., strain rate ≈0.0001 inches/inch/sec., Y.S. - 0.5% strain.	90	10					108
108b	Annealed 1472°F in vacuum - air cooled - 0.045mm. G.S. Bar sample - 0.0788 inch diam., strain rate ≈0.0001 inches/inch/sec., Y.S. - 0.5% strain.	90	10					108
263	Annealed. Bar sample - 0.505 inch diam., crosshead speed ≈0.25 inch/minute.	89.9	10.0					263
459	Wire sample, constant load applied while wire was heated at 36°F per minute until sample broke.	88.6	11.4					459



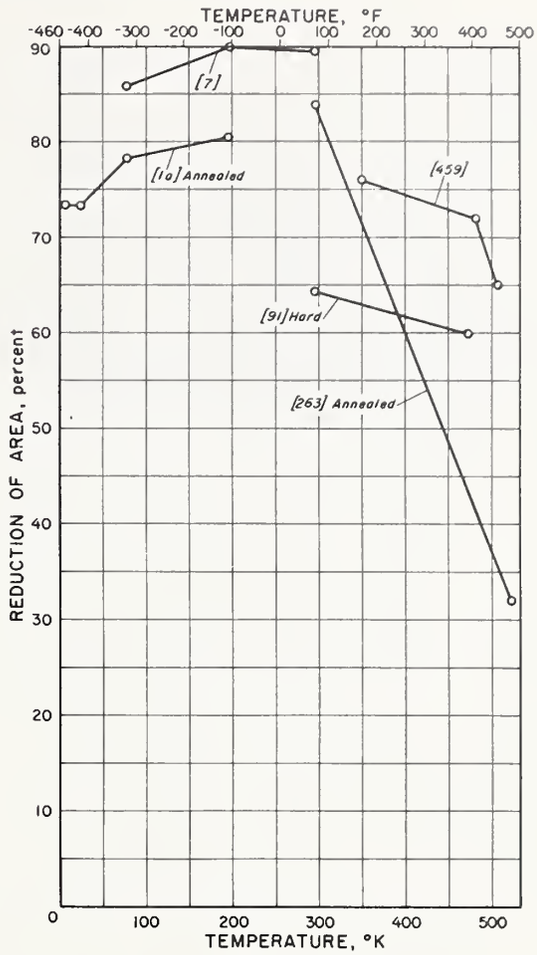
Tensile Elongation of 90Cu-10Zn (Commercial Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1067°F - 3 hrs. - 0.051mm. G.S. - R_F = 49, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, 1 inch G.L. (4 X diam.).	90.0	10.0					1
24	Wrought, 2 inch G.L.	90.0	10.0					24
91	Hard. 1.97 inch G.L.	89.6	10	0.4				91
263	Annealed. Bar sample - 0.505 inch diam., crosshead speed = 0.25 inch/minute, 2 inch G.L.	89.9	10.0					263



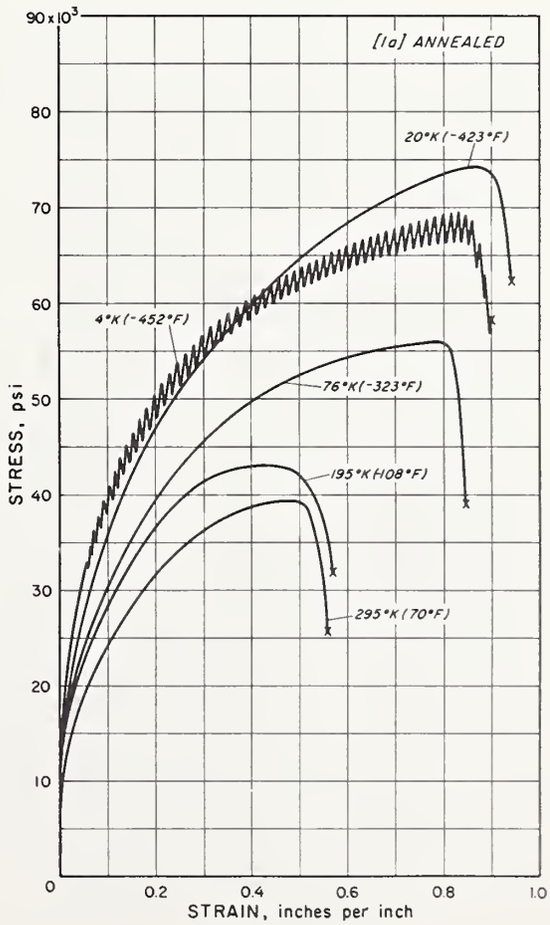
Tensile Reduction of Area of 90Cu-10Zn (Commercial Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1067°F - 3 hrs. - 0.051mm. G.S. - R_F = 49, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute.	90.0	10.0					1
7								7
91	Hard.	89.6	10	0.4				91
263	Annealed. Bar sample - 0.505 inch diam., crosshead speed ≈0.25 inch/minute.	89.9	10.0					263
459	Wire sample, constant load applied while wire was heated at 30°F per minute until sample broke.	88.6	11.4					459



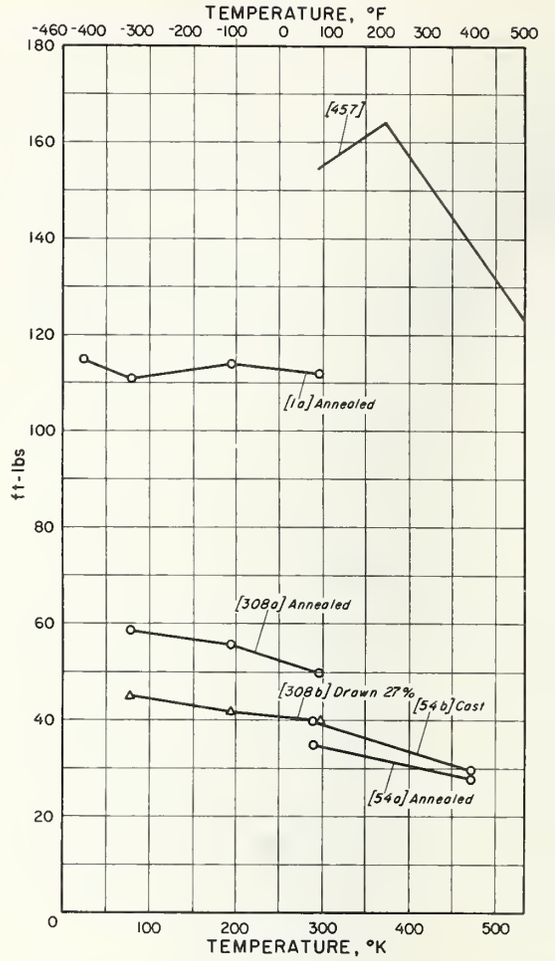
Tensile Stress-Strain Curves of 90Cu-10Zn (Commercial Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1067°F - 3 hrs. - 0.051mm. G.S. - R_F = 49, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch - crosshead speed = 0.02 inch/minute, clamp-on, strain gage extensometer - 1 inch G.L.	90.0	10.0					1



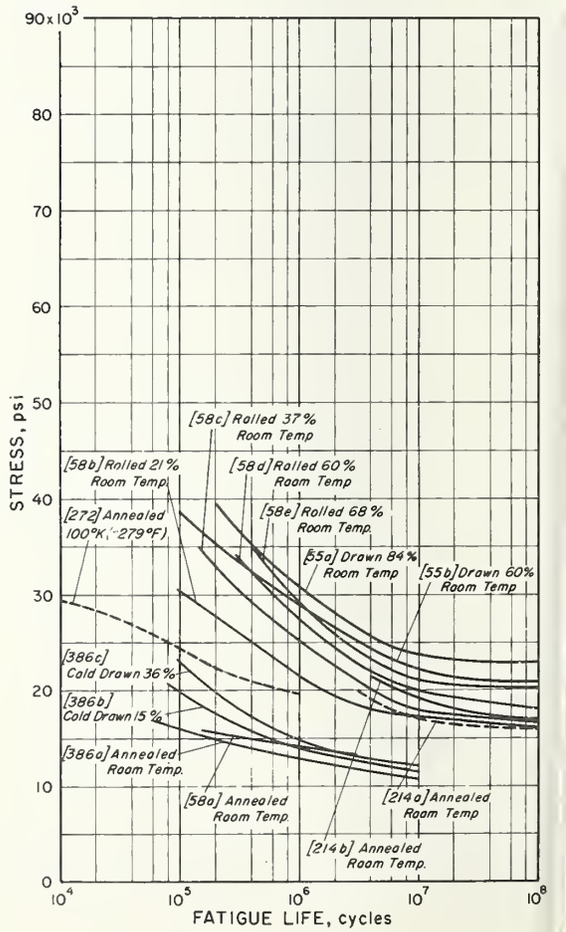
Impact Energy of 90Cu-10Zn (Commercial Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1067°F - 3 hrs. - 0.051mm. G.S. - R_F = 49, bar supplied - 3/4 inch diam. Charpy V-notch, 10% fracture - all temps., paper container glued to sample for -423°F tests, hammer velocity = 16 ft./sec.	90.0	10.0					1
54a	Annealed 1292°F - 4 hrs., bar supplied - 1/2 inch square. Izod, temperature accuracy = ± 2°F. Samples did not fracture completely: bent 70°.	90	10					54
54b	Chill - cast. Other specifications same as 54a.	90	10					54
308a	Annealed. Charpy keyhole.	90	10					308
308b	Drawn 27%. Charpy keyhole.	90	10					308
457	Assumed type sample - Mesnager: U-notch - 0.079 inch deep X 0.079 inch wide; cross section - 0.394 X 0.394 inch, point data not presented by author.	90.6	9.3					457



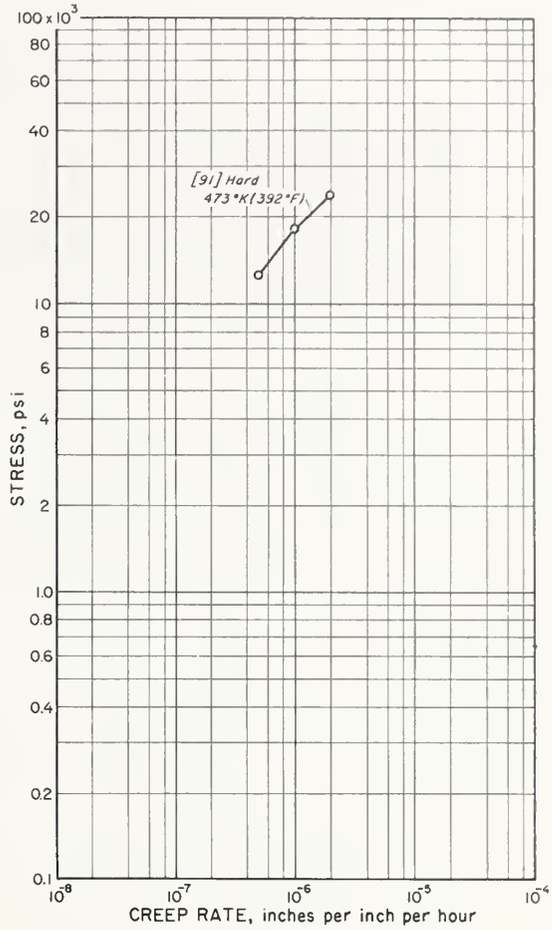
Fatigue Behavior of 90Cu-10Zn (Commercial Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
55a	Drawn 84%, room temp.: U.T.S. = 72,500 psi - Y.S. = 63,000 psi (0.2% offset). Wire sample - 0.072 inch diam., rotating arc - 3450 r.p.m., R = -1, sample at 23,000 psi - 10^8 cycles did not break.	91.20	8.80					55
55b	Drawn 60%, room temp.: U.T.S. = 61,000 psi - Y.S. = 53,500 psi (0.2% offset). Wire sample - 0.072 inch diam., rotating arc - 3450 r.p.m., R = -1.	91.20	8.80					55
58a	Annealed - 0.030mm. G.S., room temp.: U.T.S. = 39,000 psi - Y.S. = 10,400 psi (0.2% offset). Sheet sample - tapered 5-1/2 inches long X 3/8 inch wide, tested parallel to rolling direction, flexure cantilever - 900 c.p.m.	89.7	10.3					58
58b	Rolled 21% - 0.030mm. G.S., room temp.: U.T.S. = 37,700 psi. Other specifications same as 58a.	89.7	10.3					58
58c	Rolled 37% - 0.030mm. G.S., room temp.: U.T.S. = 59,700 psi - Y.S. = 53,500 psi (0.2% offset). Other specifications same as 58a.	89.7	10.3					58
58d	Rolled 60% - 0.035mm. G.S., room temp.: U.T.S. = 66,900 psi - Y.S. = 56,000 psi (0.2% offset). Other specifications same as 58a.	89.7	10.3					58
58e	Rolled 68% - 0.035mm. G.S., room temp.: U.T.S. = 73,300 psi - Y.S. = 65,000 psi (0.2% offset). Other specifications same as 58a.	89.7	10.3					58
214a	Annealed (full), room temp.: Y.S. = 18,000 psi. Rotating cantilever - 1450 r.p.m., tested in air.	91	8	1				214
214b	Tested in salt water. Other specifications same as 214a.	91	8	1				214
272	Annealed 932°F - Ar atmos. - 1 hr. - 0.022mm. G.S. Bar sample - round - electropolished, 3600 r.p.m., R = -1.	90	10					272
386a	Annealed 600°C - 2 hrs., room temp.: U.T.S. = 38,400 psi - Y.S. = 10,400 psi (0.2% offset), R_F = 52.1. Bar sample - 0.63 inch diam.	90.0	10.0					386
386b	Cold drawn 15%, room temp.: U.T.S. = 46,800 psi - Y.S. = 43,600 psi (0.2% offset), R_B = 49.5. Bar sample - 0.71 inch diam.	90.0	10.0					386
386c	Cold drawn 36%, room temp.: U.T.S. = 56,000 psi - Y.S. = 52,000 psi (0.2% offset), R_B = 57.5. Bar sample - 0.63 inch diam.	90.0	10.0					386



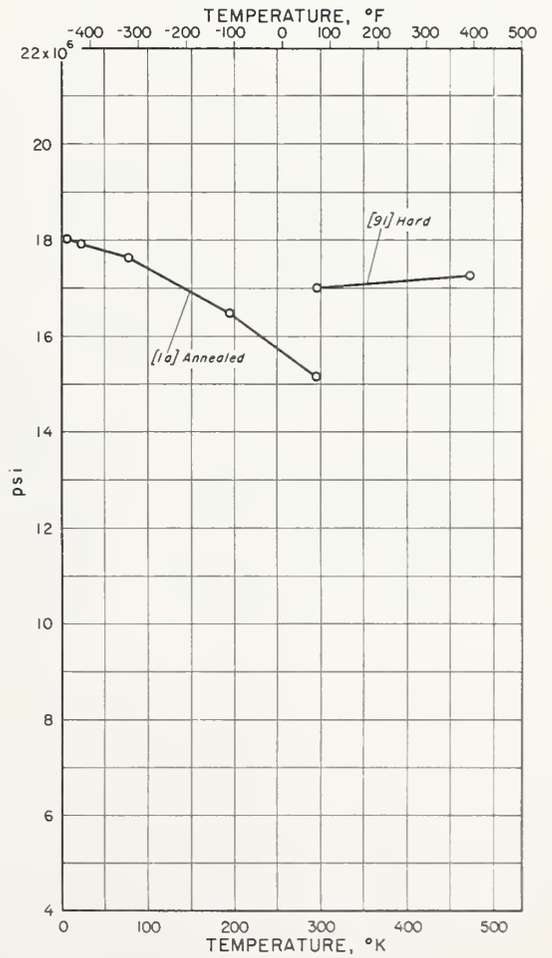
Creep Behavior of 90Cu-10Zn (Commercial Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
91	Hard. Rate taken at 1000 hrs.	89.6	10	0.4				91



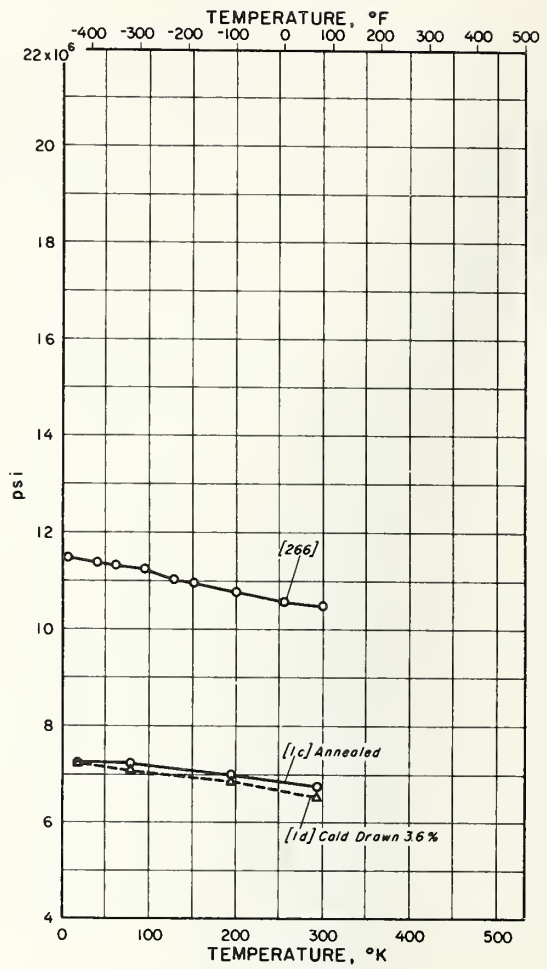
Modulus of Elasticity of 90Cu-10Zn (Commercial Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1067°F - 3 hrs. - 0.051mm. G.S. - R_F = 49, bar supplied - 3/4 inch diam. Bar sample - 0.250 inch diam. X 1.50 inches long reduced section, clamp-on strain gage extensometer - 1 inch G.L., 0.02 inch per minute cross-head speed, data spread = ± 5%.	90.0	10.0					1
91	Hard.	89.6	10	0.4				91



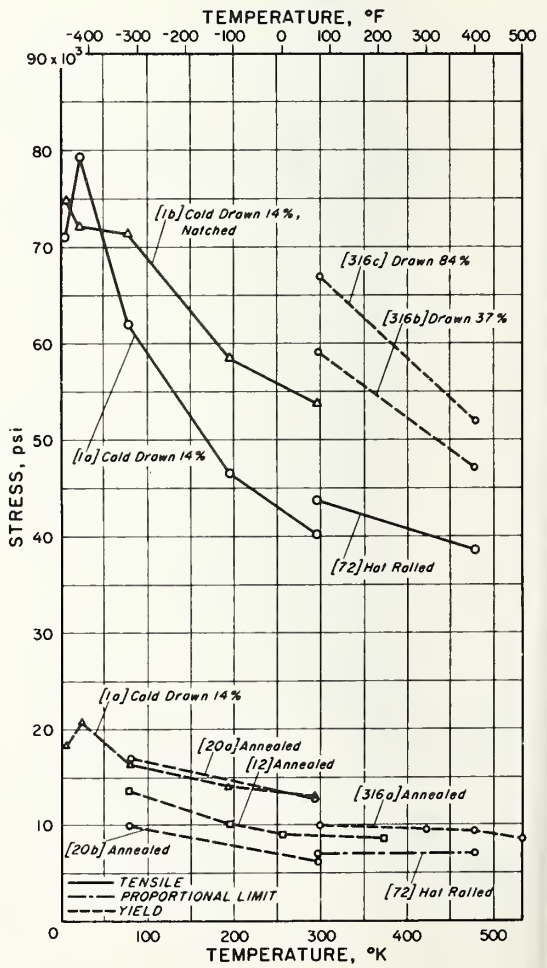
Modulus of Rigidity of 90Cu-10Zn (Commercial Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1c	Annealed 1000°F - 1/2 hr. - in vacuum - air cooled, bar supplied - 3/4 inch diam. Bar sample - reduced section: 2.5 inches long X 1/8 inch diam., shear modulus determined isothermally by applying weights, maximum shear stress of 350 psi, data spread = ± 2%.	90.0	10.0					1
1d	Cold drawn 3.6%. Other specifications same as 1c.	90.0	10.0					1
266	Single crystal - [110] orientation (within 1°). Ultrasonic pulse - 10 Mc.p.s. Bar sample - 5/8 inch diam. X 5/8 inch long, measured shear constant C_{44}.	90.5	9.5					266



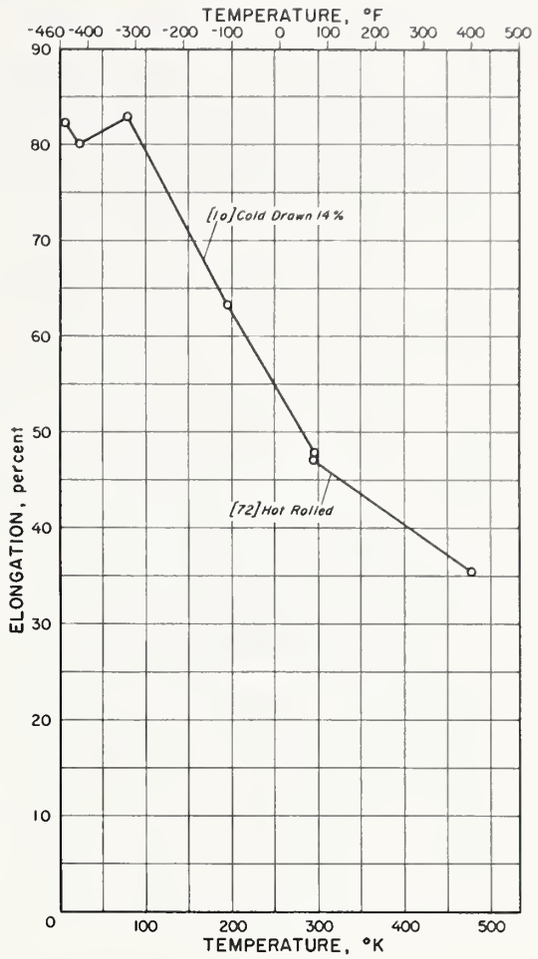
Tensile and Yield Strength of 85Cu-15Zn (Red Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Cold drawn 14% - 0.025mm. G.S. - R_F = 64, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, Y.S. - 0.2% offset.	84.7	15.3					1
1b	Notched sample - 0.25 inch diam. at circumferential notch roots, 0.005 ± 0.0005 inch notch radius (K_T = 5.0). Other specifications same as 1a.	84.7	15.3					1
12	Annealed 752°F - 1 hr. - 0.027mm. G.S. Wire sample - 0.039 inch diam., strain rate = 0.001 inch/inch/minute, Y.S. - 0.01% offset.	84.2	15.8					12
20a	Annealed - 0.016mm. G.S. - after hot reducing 75% and cold rolling 40%. Bar sample - 1/4 inch diam., strain rate = 0.0028 inch/inch/minute.	84.3	15.7					20
20b	Annealed - 0.113mm. G.S. Other specifications same as 20a.	84.3	15.7					20
72	Hot rolled - 0.030mm. G.S., bar supplied - 3/4 inch diam.	85.0	14.9					72
316a	Annealed - 0.060mm. G.S. Bar sample - 0.125 inch diam. Y.S. - 0.5% strain.	84.8	15.2					316
316b	Drawn 37%. Bar sample - 0.125 inch diam., Y.S. - 0.5% strain.	84.8	15.2					316
316c	Drawn 84%. Bar sample - 0.125 inch diam., Y.S. - 0.5% strain.	84.8	15.2					316



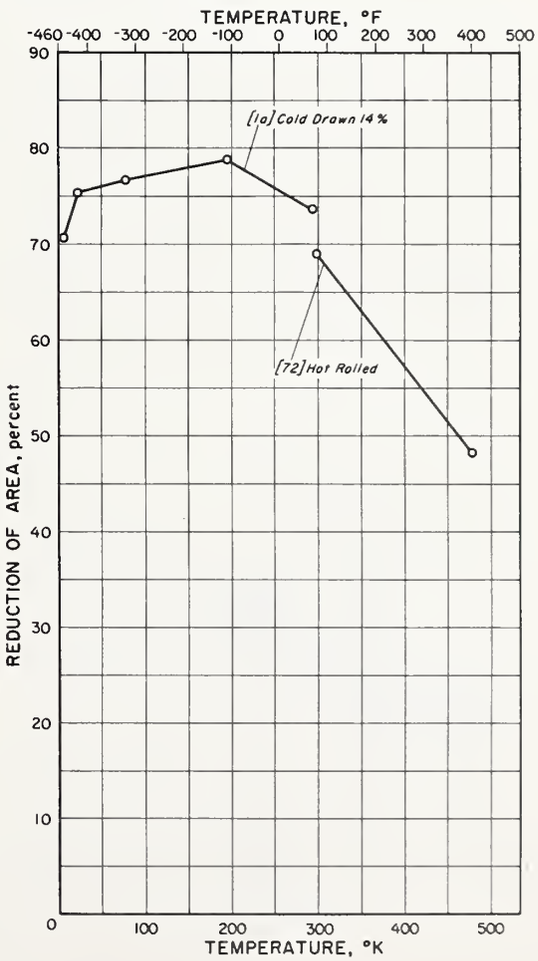
Tensile Elongation of 85Cu-15Zn (Red Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Cold drawn 14% - 0.025mm. G.S. - R_F = 64, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, 1 inch G.L. (4 X diam.).	84.7	15.3					1
72	Hot rolled - 0.030mm. G.S., bar supplied - 3/4 inch diam.	85.0	14.9					72



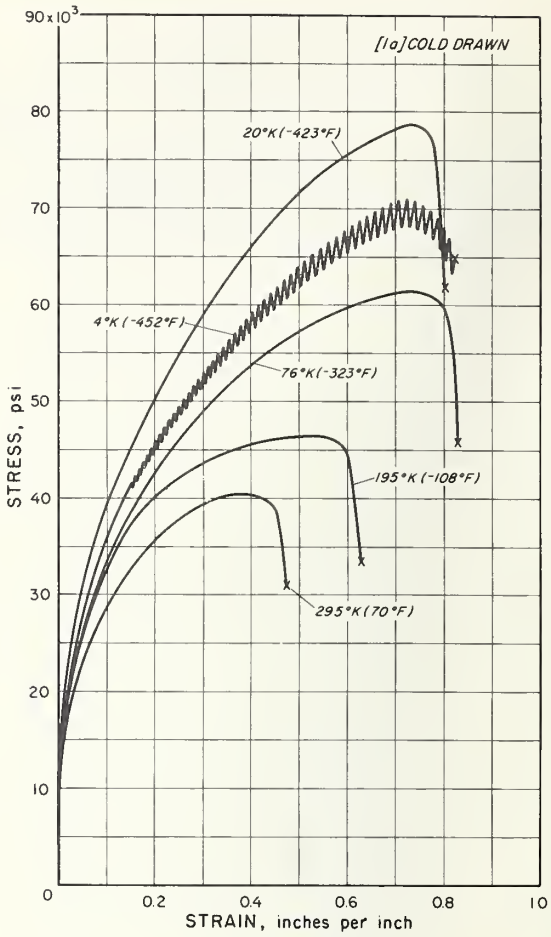
Tensile Reduction of Area of 85Cu-15Zn (Red Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Cold drawn 14% - 0.025mm. G.S. - R_F = 64, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute.	84.7	15.3					1
72	Hot rolled - 0.030mm G.S., bar supplied - 3/4 inch diam.	85.0	14.9					72



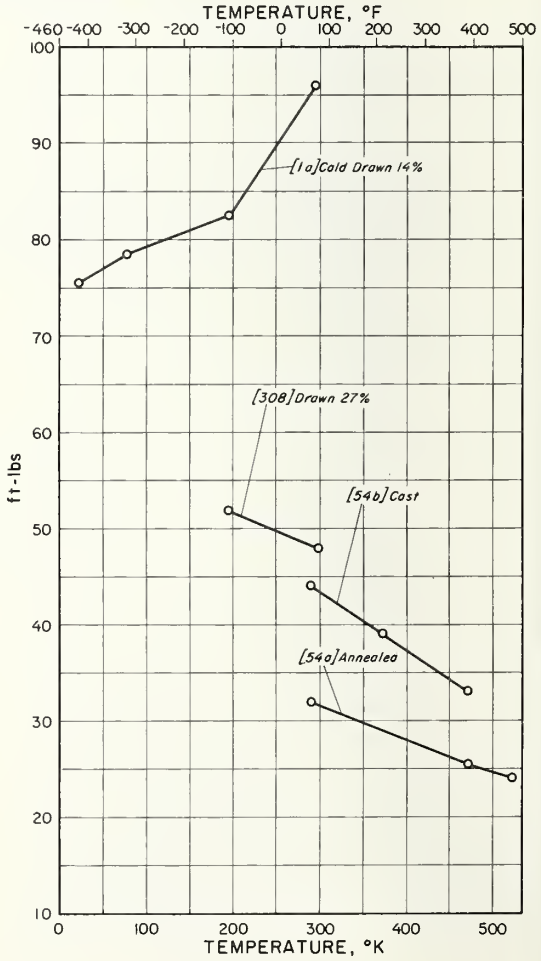
Tensile Stress-Strain Curves of 85Cu-15Zn (Red Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Cold drawn 14% - 0.025mm. G.S. - R_F = 64, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer - 1 inch G.L.	84.7	15.3					1



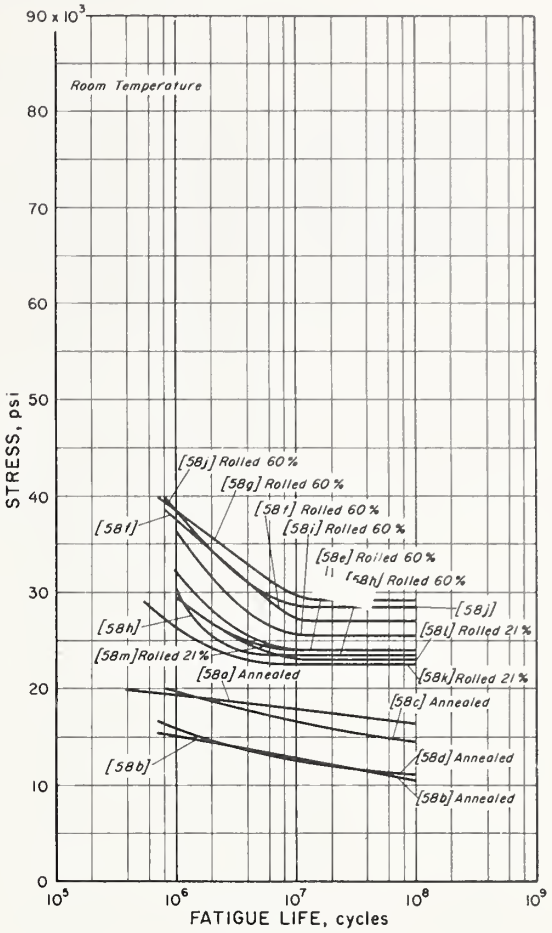
Impact Energy of 85Cu-15Zn (Red Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Cold drawn 14% - 0.025mm. G.S. - R_F = 64, bar supplied - 3/4 inch diam. Charpy V-notch, 95% fracture - all temps., paper container glued to sample for -423°F, hammer velocity = 16 ft./sec.	84.7	15.3					1
54a	Annealed 1292°F - 4 hrs., bar supplied - 1/2 inch square. Izod, samples did not fracture completely: bent 70°, temperature accuracy = ± 2°F.	87	13					54
54b	Chill - cast. Other specifications same as 54a.	87	13					54
308	Drawn 27%. Charpy keyhole.	85	15					308

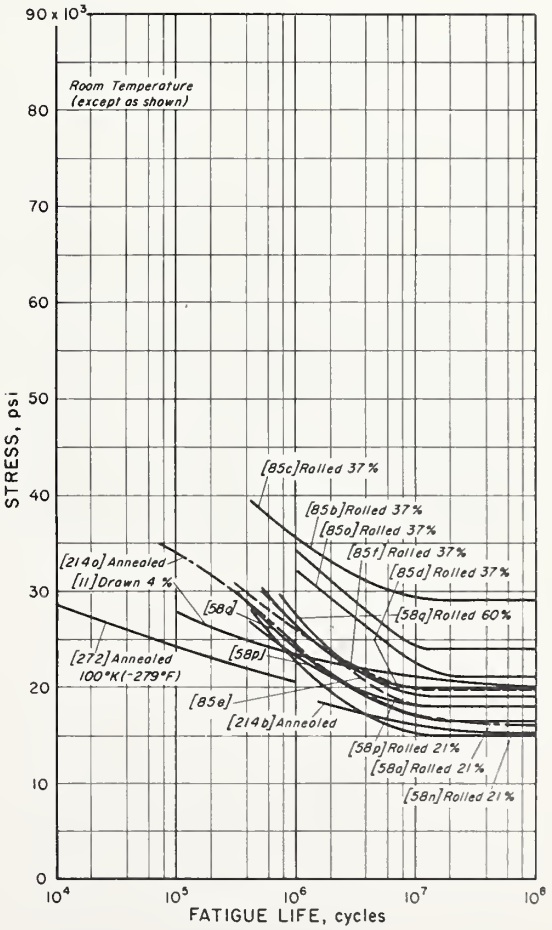


Fatigue Behavior of 85Cu-15Zn (Red Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
58a	Annealed - 0.020mm. G.S., room temp.: U.T.S. = 44,000 psi, sheet supplied - 0.032 inch thick. Sheet sample - tapered - 5-1/2 inches long X 3/8 inch wide, flexure cantilever - 900 c.p.m., data spread ± 5%.	85.0	15.0					58
58b	Annealed - 0.075mm. G.S., room temp.: U.T.S = 39,000 psi. Other specifications same as 58a.	85.0	15.0					58
58c	Annealed - 0.025mm. G.S., room temp.: U.T.S. = 42,000 psi - Y.S. = 13,500 psi (0.5% strain). Other specifications same as 58a.	85.0	15.0					58
58d	Annealed - 0.090mm. G.S., room temp.: U.T.S. = 33,500 psi - Y.S. = 8,800 psi (0.5% strain). Other specifications same as 58a.	85.0	15.0					58
58e	Rolled 60% - 0.025mm. G.S., room temp.: U.T.S. = 79,000 psi. Other specifications same as 58a.	85.0	15.0					58
58f	Rolled 60% - room temp.: U.T.S. = 80,500 psi - Y.S. = 63,400 psi (0.5% strain). Tested 45° to rolling direction. Other specifications same as 58a.	85.0	15.0					58
58g	Rolled 60% - room temp.: U.T.S. = 88,000 psi. Tested 90° to rolling direction. Other specifications same as 58a.	85.0	15.0					58
58h	Rolled 60% - 0.070mm. G.S., room temp.: U.T.S. = 79,000 psi. Other specifications same as 58a.	85.0	15.0					58
58i	Rolled 60% - room temp.: U.T.S. = 83,000 psi. Tested 45° to rolling direction. Other specifications same as 58a.	85.0	15.0					58
58j	Rolled 60% - room temp.: U.T.S. = 91,000 psi. Tested 90° to rolling direction. Other specifications same as 58a.	85.0	15.0					58
58k	Rolled 21% - 0.020mm. G.S., room temp.: U.T.S = 56,500 psi. Other specifications same as 58a.	85.0	15.0					58
58l	Rolled 21% - room temp.: U.T.S. = 52,000 psi - Y.S. = 48,400 psi (0.5% strain). Tested 45° to rolling direction. Other specifications same as 58a.	85.0	15.0					58
58m	Rolled 21% - room temp.: U.T.S. = 56,000 psi. Tested 90° to rolling direction. Other specifications same as 58a.	85.0	15.0					58

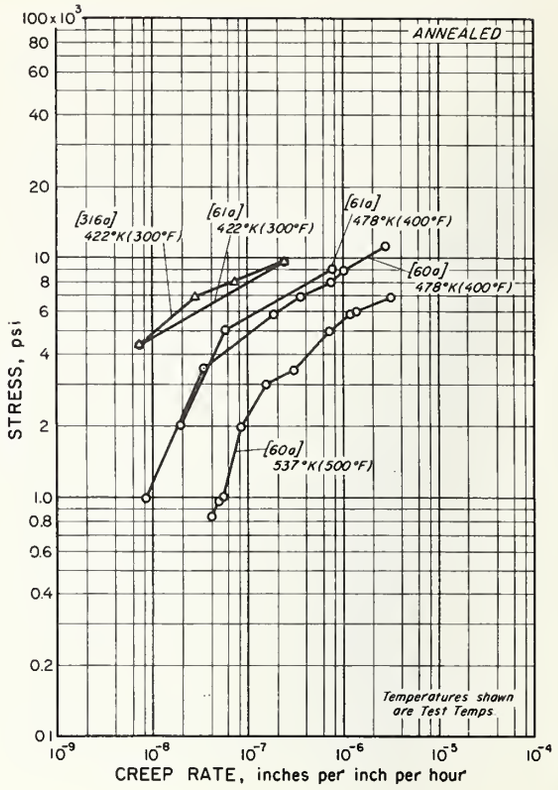


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
11	Drawn 4% - 0.025mm. G.S., room temp.: U.T.S. = 44,700 psi - Y.S. = 28,200 psi, bar supplied - 1/2 inch diam. Bar sample - 0.30 inch diam., rotating beam.	84.5	15.4				<0.1Fe, <0.1Pb	11
58n	Rolled 21% - 0.060mm. G.S., room temp.: U.T.S. = 50,000 psi - Y.S. = 45,800 psi (0.5% strain), sheet supplied - 0.032 inch thick. Sheet sample - tapered - 5-1/2 inches long X 3/8 inch wide, flexure cantilever - 900 c.p.m. data spread ± 5%.	85.0	15.0					58
58o	Rolled 21% - room temp.: U.T.S. = 43,500 psi - Y.S. = 44,300 psi (0.5% strain). Tested 45° to rolling direction. Other specifications same as 58n.	85.0	15.0					58
58p	Rolled 21% - room temp.: U.T.S. = 50,000 psi - Y.S. = 45,600 psi (0.5% strain). Tested 90° to rolling direction. Other specifications same as 58n.	85.0	15.0					58
58q	Rolled 60% - room temp.: U.T.S.= 83,300 psi - Y.S. = 74,000 psi (0.2% offset), plate supplied - 0.032 inch thick. Sheet sample - tapered - 5-1/2 inches long X 3/8 inch wide, tested in rolling direction, flexure cantilever - 900 c.p.m., data spread ± 5%.	85.3	13.7	1.0				58
85a	Rolled 37% - 0.030mm. G.S., room temp.: U.T.S. = 69,000 psi - Y.S. = 59,700 psi (0.5% strain), sheet supplied - 0.032 inch thick. Sheet sample - tapered - 5-1/2 inches long X 3/8 inch wide, tested in rolling direction, flexure cantilever - 900 c.p.m., data spread ± 5%.	85.0	15.0					85
85b	Rolled 37% - room temp.: U.T.S. = 69,500 psi - Y.S = 58,600 psi (0.5% strain). Tested 45° to rolling direction. Other specifications same as 85a.	85.0	15.0					35
85c	Rolled 37% - room temp.: U.T.S. = 75,000 psi - Y.S. = 64,500 psi (0.5% strain). Tested 90° to rolling direction. Other specifications same as 85a.	85.0	15.0					85
85d	Rolled 37% - room temp.: U.T.S. = 64,000 psi - Y.S. = 56,500 psi (0.5% strain). Other specifications same as 85a.	85.0	15.0					85
85e	Rolled 37% - room temp.: U.T.S. = 63,000 psi - Y.S. = 55,600 psi (0.5% strain). Tested 45° to rolling direction. Other specifications same as 85a.							85
85f	Rolled 37% - room temp.: U.T.S. = 66,000 psi - Y.S = 57,800 psi (0.5% strain). Tested 90° to rolling direction. Other specifications same as 85a.							85
214a	Annealed (stress relief), room temp.: Y.S. = 34,500 psi. Rotating cantilever - 1450 r.p.m., tested in air.							214
214b	Annealed (full), room temp.: Y.S. = 11,000 psi. Rotating cantilever - 1450 r.p.m., tested in salt water.							214
272	Annealed 932°F, Ar atmos. - 1 hr. - 0.020mm. G.S. Bar sample - round - electropolished - 3600 r.p.m., R = -1.	85	15					272

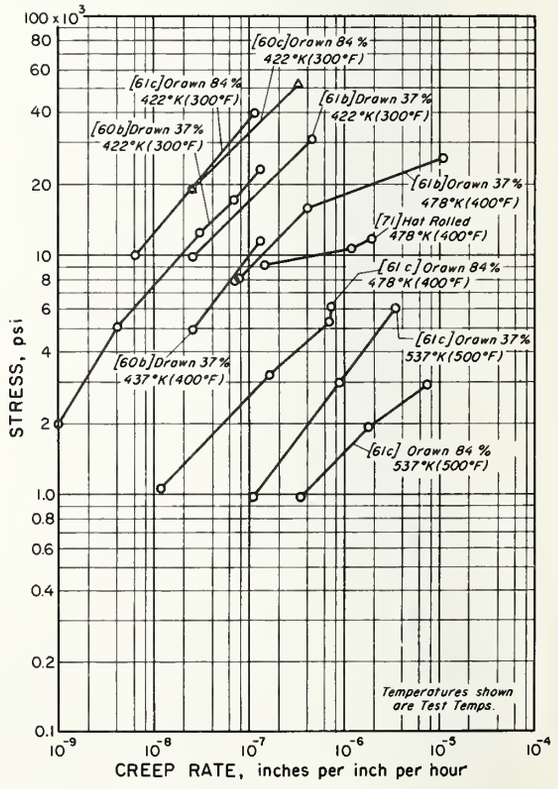


Creep Behavior of 85Cu-15Zn (Red Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
60a	Annealed - 0.060mm. G.S., room temp.: U.T.S. = 41,000 psi - Y.S. = 9,000 psi (0.5% strain). Bar sample - 1/8 inch diam., 10 inch G.L.	84.8	15.2					60
61a	Annealed - 0.060mm. G.S., room temp.: U.T.S. = 41,000 psi - Y.S. = 9,000 psi (0.5% strain). Bar sample - 1/8 inch diam., rates taken at 4500 hrs., 10 inch G.L.	84.8	15.2					61
316a	Annealed - 0.060mm. G.S. Bar sample - 0.125 inch diam., second stage creep.	84.8	15.2					316

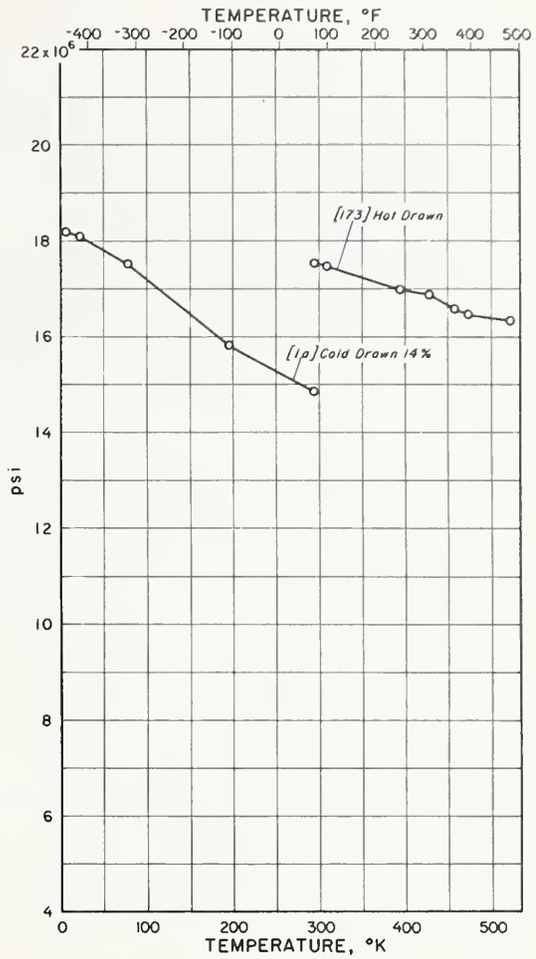


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
60b	Drawn 37%, room temp.: U.T.S. = 67,000 psi - Y.S. = 59,000 psi (0.5% strain). Bar sample - 1/8 inch diam., 10 inch G.L.	84.8	15.2					60
60c	Drawn 84%, room temp.: U.T.S. = 96,500 psi - Y.S. = 67,000 psi (0.5% strain). Bar sample - 1/8 inch diam., rates taken at 5100 hrs., 10 inch G.L.	84.8	15.2					60
61b	Drawn 37%, room temp.: U.T.S. = 67,500 psi - Y.S. = 59,000 psi (0.5% strain). Bar sample - 1/8 inch diam., rates taken at 4800 hrs., 10 inch G.L.	84.8	15.2					61
61c	Drawn 84%, room temp.: U.T.S. = 96,500 psi - Y.S. = 67,000 psi (0.5% strain). Bar sample - 1/8 inch diam., rates taken approx. 4400 hrs., 10 inch G.L.	84.8	15.2					61
71	Hot rolled - 0.030mm. G.S, bar supplied - 3/4 inch diam.	85.0	14.9					71



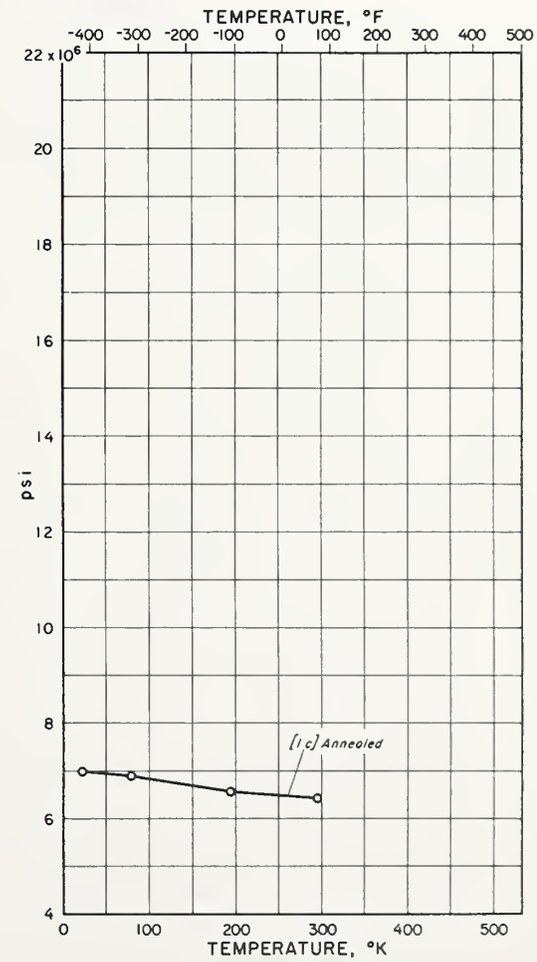
Modulus of Elasticity of 85Cu-15Zn (Red Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Cold drawn 14% - 0.025mm. G. S. - R_F = 64, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.250 inch diam., crosshead speed = 0.02 inch/minute, 1 inch G. L., determined isothermally using clamp-on, strain gage extensometer.	84.7	15.3					1
173	Hot drawn. Bar sample - 0.288 inch diam. - approx. 7 inches long, transverse vibration.	85	15					173



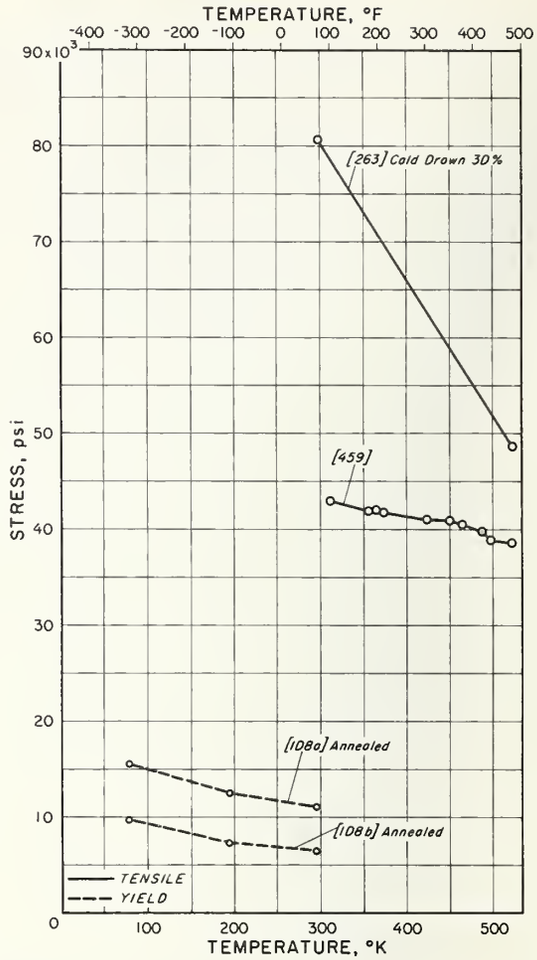
Modulus of Rigidity of 85Cu-15Zn (Red Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1c	Annealed 1000°F - 1/2 hr., bar supplied - 3/4 inch diam. Bar sample - 1/8 inch diam., sample reduced length = 2.5 inches, determined isothermally by applying weights, maximum shear stress of 350 psi, data spread = ± 2%.	84.7	15.3					1



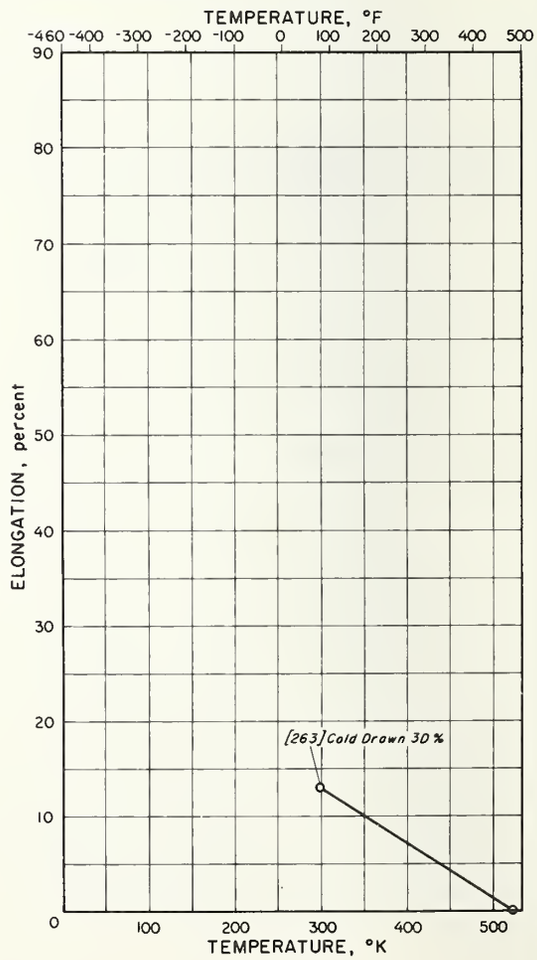
Tensile and Yield Strength of 80Cu-20Zn (Low Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
108a	Annealed 1112°F in vacuum - air cooled - 0.03mm. G.S. Bar sample - 0.0788 inch diam., strain rate ≈0.0001 inch/inch/sec., Y.S. - 0.5% strain.	80	20					108
108b	Annealed 1472°F in vacuum - air cooled - 0.045mm. G.S. Bar sample - 0.0788 inch diam., strain rate ≈0.0001 inch/inch/sec., Y.S. - 0.5% strain.	80	20					108
263	Cold drawn 30%. Bar sample - 0.505 inch diam., cross-head speed ≈0.25 inch/minute.	80.1	19.9					263
459	Wire sample, constant load applied while wire was heated at 36°F/minute until sample broke.	81.3	18.7					459



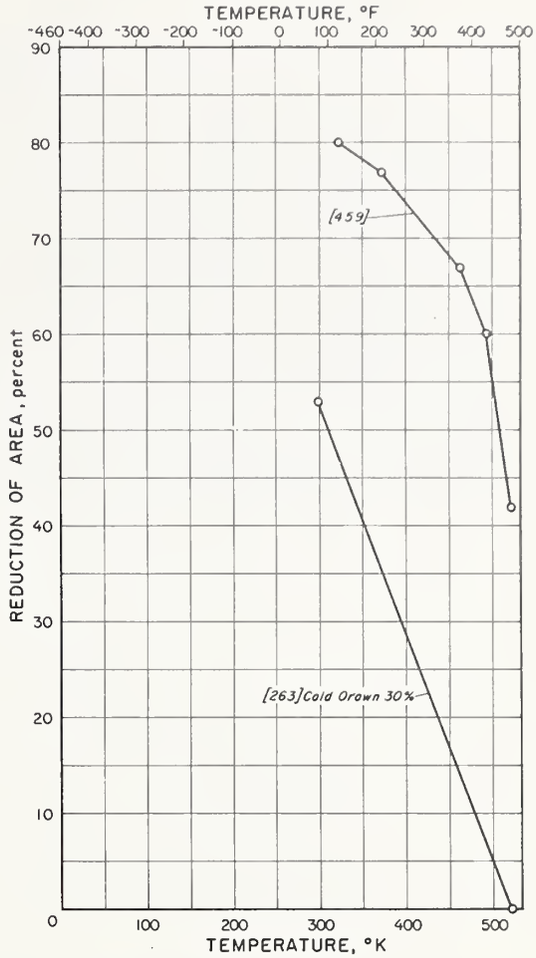
Tensile Elongation of 80Cu-20Zn (Low Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
263	Cold drawn 30%. Bar sample - 0.505 inch diam., cross-head speed ≈0.25 inch/minute, 2 inch G.L.	80.1	19.9					263



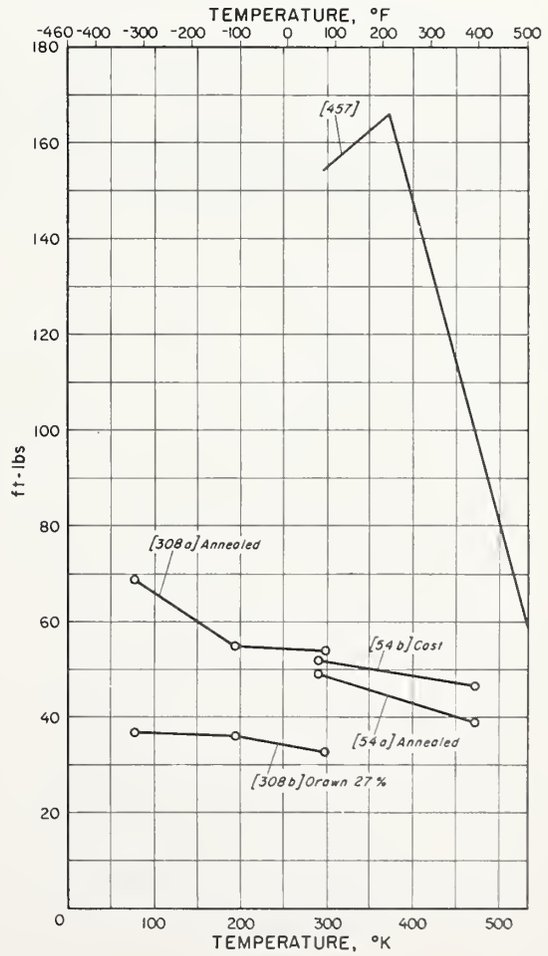
Tensile Reduction of Area of 80Cu-20Zn (Low Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
263	Cold drawn 30%. Bar sample - 0.505 inch diam., cross-head speed ≈ 0.25 inch/minute.	80.1	19.9					263
459	Wire sample. Constant load applied while wire was heated at 36°F/minute until sample broke.	81.3	18.7					459



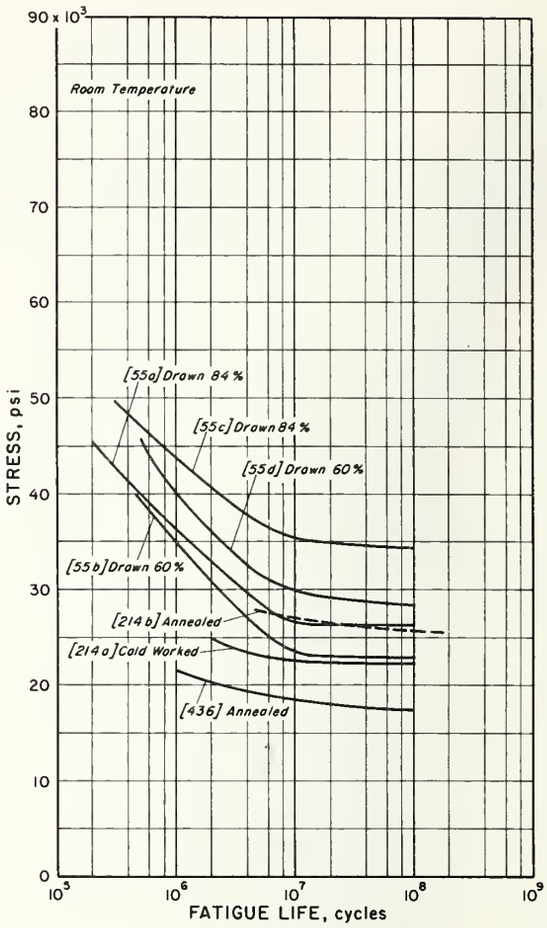
Impact Energy of 80Cu-20Zn (Low Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
54a	Annealed 1292°F - 4 hrs., bar supplied - 1/2 inch square. Izod, samples did not fracture completely: bent 65°, temp. accuracy = ± 2°F.	80	20					54
54b	Chill - cast. Other specifications same as 54a.	80	20					54
308a	Annealed. Charpy keyhole.	80	20					308
308b	Drawn 27%. Charpy keyhole.	80	20					308
457	Assumed type sample - Mesnager: U-notch - 0.079 inch deep X 0.079 inch wide; cross-section - 0.394 X 0.394 inch, point data not presented by author.	81.0	18.3				0.3Sn, 0.3Pb, 0.1Fe	457



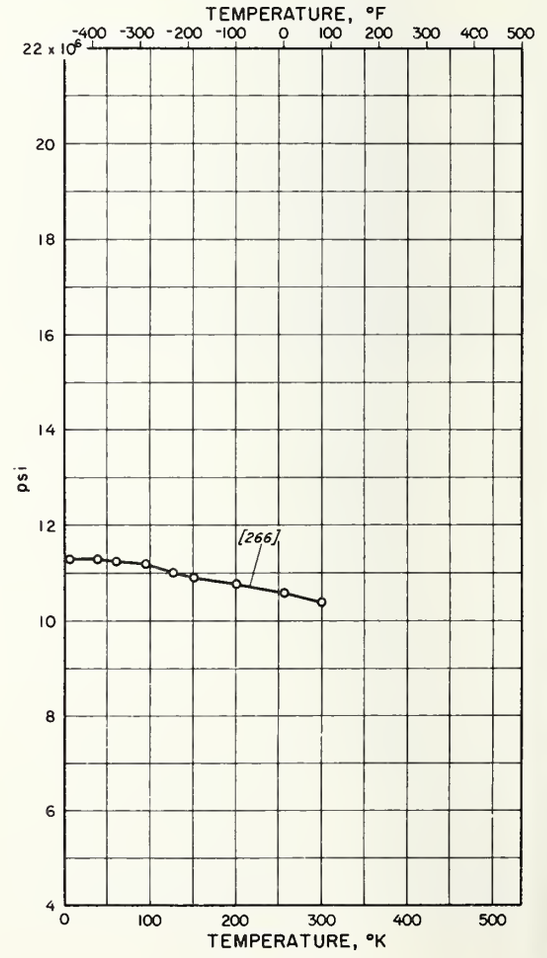
Fatigue Behavior of 80Cu-20Zn (Low Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
55a	Drawn 84%, room temp.: U. T. S. = 108,000 psi - Y. S. = 80,500 psi (0.2% offset). Wire sample - 0.072 inch diam., rotating arc - 3450 r.p.m., R = -1, samples at 26,500 and 25,000 psi - 10^8 cycles did not break.	80.1	19.9					55
55b	Drawn 60%, room temp.: U. T. S. = 89,000 psi - Y. S. = 67,500 psi (0.2% offset). Wire sample - 0.072 inch diam., rotating arc - 3450 r.p.m., R = -1, samples at 23,000 and 22,500 psi - 10^8 cycles did not break.	80.1	19.9					55
55c	Drawn 84%, room temp.: U. T. S. = 125,000 psi - Y. S. = 93,000 psi (0.2% offset). Wire sample - 0.072 inch diam., rotating arc - 3450 r.p.m., R = -1, sample at 34,000 psi - 10^8 cycles did not break.	79.9	19.3	0.8				55
55d	Drawn 60%, room temp.: U. T. S. = 104,000 psi - Y. S. = 79,000 psi (0.2% offset). Wire sample - 0.072 inch diam., rotating arc - 3450 r.p.m., R = -1, sample at 28,000 psi - 10^8 cycles did not break.	79.9	19.3	0.8				55
214a	Cold worked (in fabrication). Rotating cantilever - 1450 r.p.m.							214
214b	Annealed (stress relief). Rotating cantilever - 1450 r.p.m.							214
436	Annealed, room temp.: U. T. S. = 44,000 psi, Y. S. = 11,800 psi. Rotating cantilever.	80.8	19.1				0.1Fe	436



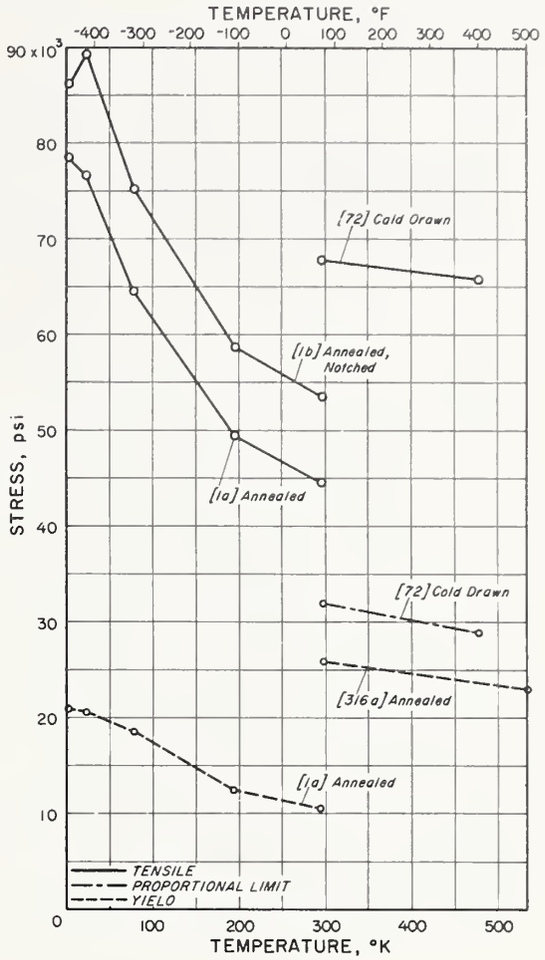
Modulus of Rigidity of 80Cu-20Zn (Low Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
266	Single crystal - [110] orientation (within 1°). Bar sample - 5/8 inch diam. X 5/8 inch long, ultrasonic pulse - 10Mc. p.s. measured shear constant C_{44}.	82.3	17.7					266



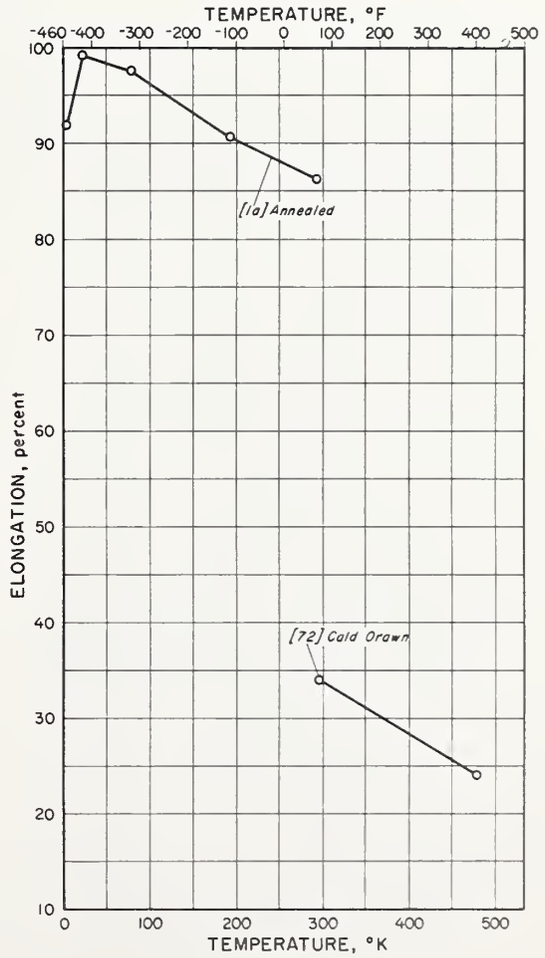
Tensile and Yield Strength of 71Cu-28Zn-1Sn (Admiralty Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1067°F - 3 hrs. - 0.144mm. G.S. - R_F = 55, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long - 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, Y.S. - 0.2% offset.	71.4	27.6	1.0				1
1b	Notched sample - 0.25 inch diam. at circumferential notch roots - 0.005 ± 0.0005 inch notch radius (K_T = 5.0). Other specifications same as 1a.	71.4	27.6	1.0				1
72	Cold drawn, bar supplied - 3/4 inch diam.	71.0	28.0	1.0				72
316a	Annealed - 0.018mm. G.S., bar supplied - 0.125 inch diam., Y.S. - 0.5% strain.	71.1	28.0	0.90				316



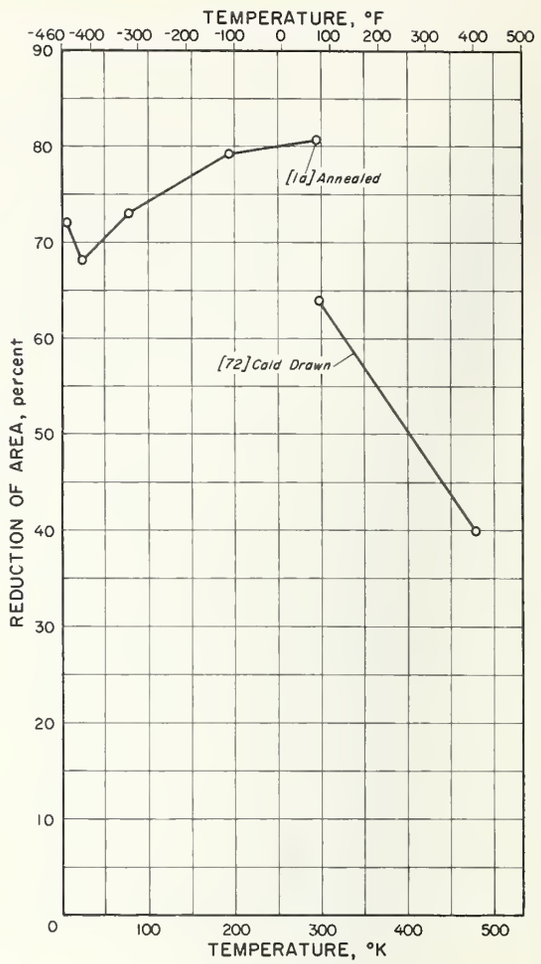
Tensile Elongation of 71Cu-28Zn-1Sn (Admiralty Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1067°F - 3 hrs. - 0.144mm. G.S. - R_F = 55, bar supplied - 3/4 inch diam. Bar sample - reduced section 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, 1 inch G.L. (4 X diam.).	71.4	27.6	1.0				1
72	Cold drawn, bar supplied - 3/4 inch diam. 2 inch G.L.	71.0	28.0	1.0				72



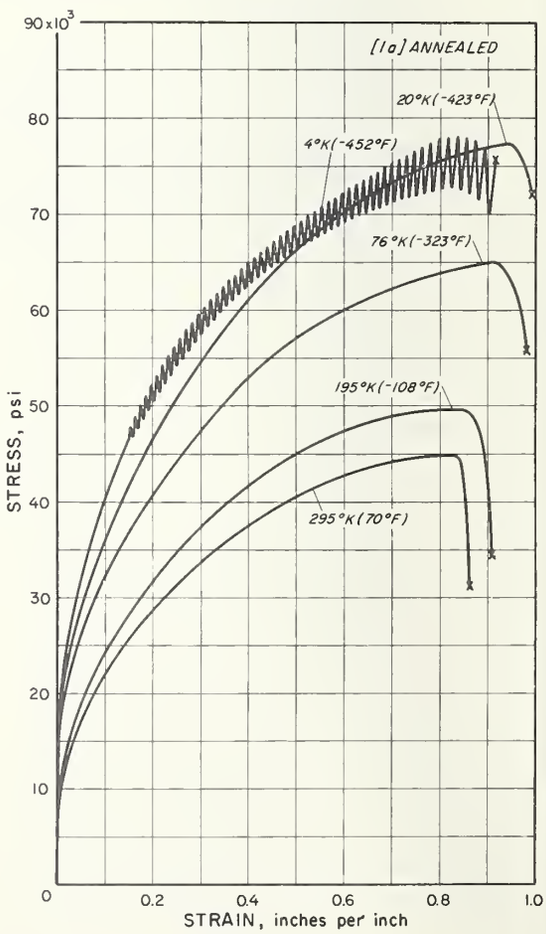
Tensile Reduction of Area of 71Cu-28Zn-1Sn (Admiralty Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1067°F - 3 hrs. - 0.144mm. G.S. - R_F = 55, bar supplied - 3/4 inch diam. Bar sample - reduced section 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute.	71.4	27.6	1.0				1
72	Cold drawn, bar supplied - 3/4 inch diam.	71.0	28.0	1.0				72



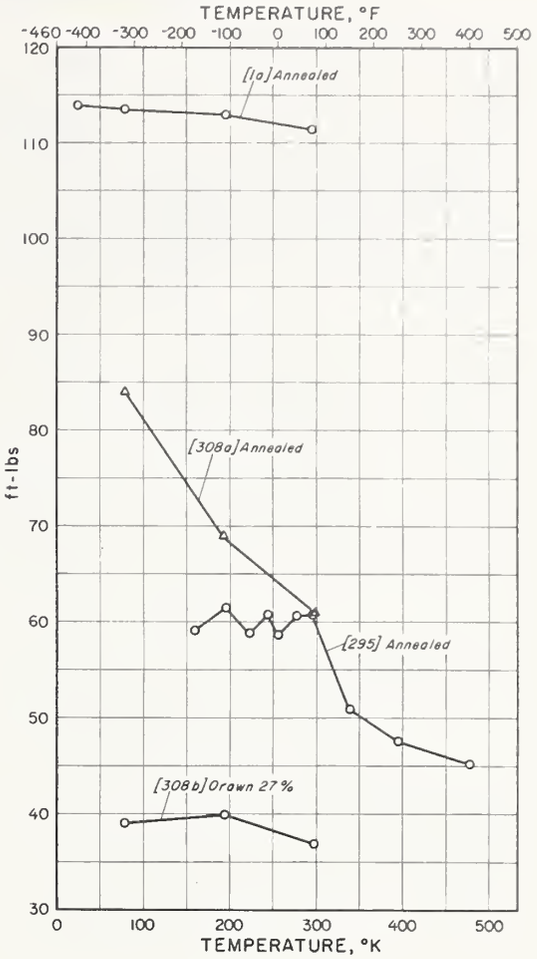
Tensile Stress-Strain Curves of 71Cu-28Zn-1Sn (Admiralty Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1067°F - 3 hrs. - 0.144mm. G.S. - R_F = 55, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer - 1 inch G.L.	71.4	27.6	1.0				1



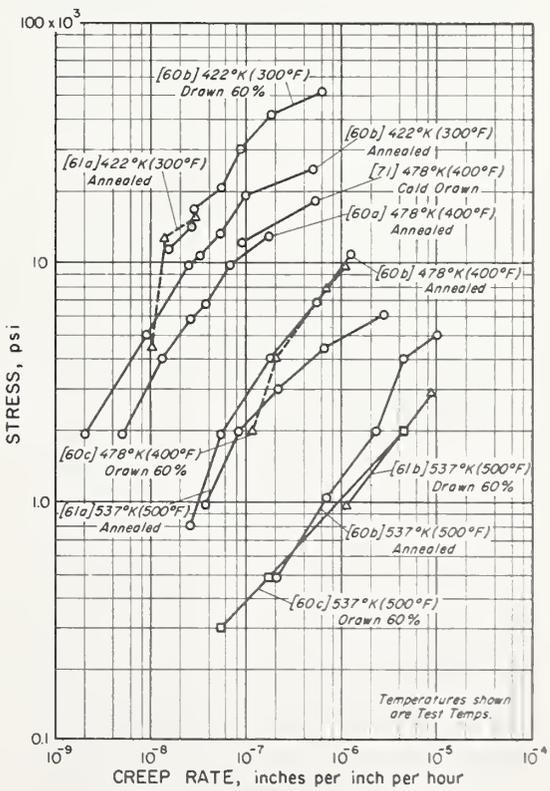
Impact Energy of 71Cu-28Zn-1Sn (Admiralty Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1067°F - 3 hrs. - 0.144mm. G.S. - R_F = 55, bar supplied - 3/4 inch diam. Charpy V-notch, 10% fracture - all temps., paper container glued to sample for -423°F tests, hammer velocity = 16 ft./sec.	71.4	27.6	1.0				1
295	Annealed, R_F = 64, bar supplied - 3/4 inch diam. Charpy keyhole, partial fracture - all temps., -175°F - ether and liquid air - other test temperatures by warming from -175°F, 3 tests/temp.	70.6	28.4	1.0				295
308a	Annealed. Charpy keyhole.	71.0	28.0	1.0				308
308b	Drawn 27%. Charpy keyhole.	71.0	28.0	1.0				308



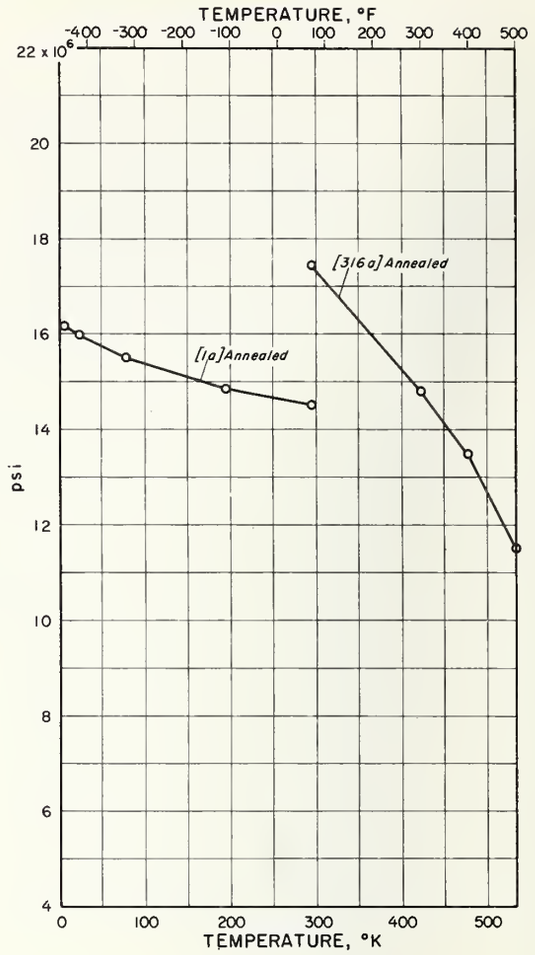
Creep Behavior of 71Cu-28Zn-1Sn (Admiralty Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
60a	Annealed - 0.055mm. G.S., room temp.; U.T.S. = 52,000 psi - Y.S. = 15,500 psi (0.5% strain). Bar sample - 1/8 inch diam., 10 inch G.L.	71.1	28.0	0.9				60
60b	Annealed - 0.018mm. G.S., room temp.; U.T.S. = 57,000 psi - Y.S. = 26,000 psi (0.5% strain). Bar sample - 1/8 inch diam., 10 inch G.L.	71.1	28.0	0.9				60
60c	Drawn 60%, room temp.; U.T.S. = 109,000 psi - Y.S. = 71,000 psi (0.5% strain). Bar sample - 1/8 inch diam., 10 inch G.L.	71.1	28.0	0.9				60
61a	Annealed - 0.055mm. G.S., room Temp.: U.T.S. = 52,000 psi - Y.S. = 15,500 psi (0.5% strain). Bar sample - 1/8 inch diam., 10 inch G.L.	71.1	28.0	0.9				61
61b	Drawn 60%, room temp.: U.T.S. = 109,000 psi - Y.S. = 71,000 psi (0.5% strain). Bar sample - 1/8 inch diam.	71.1	28.0	0.9				61
71	Cold drawn, bar supplied - 3/4 inch diam.	71.0	28.0	1.0				71



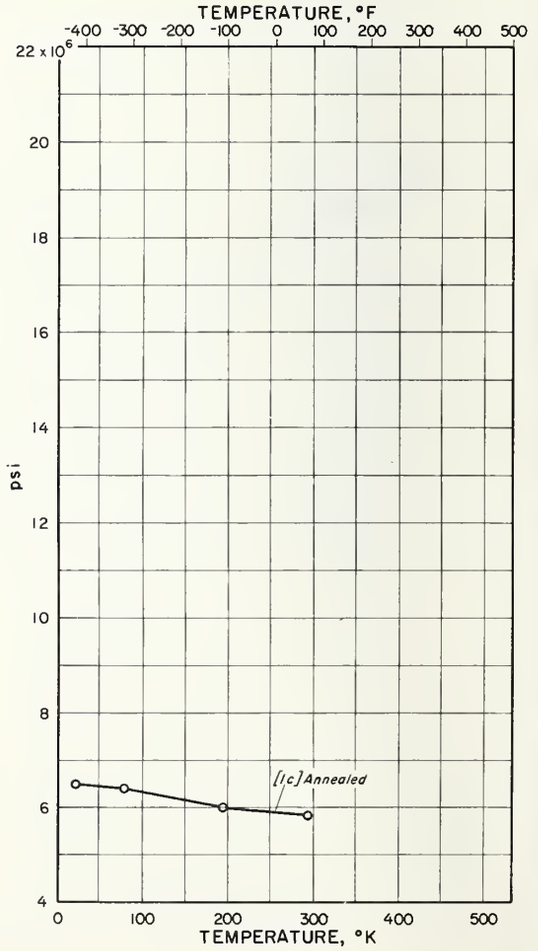
Modulus of Elasticity of 71Cu-28Zn-1Sn (Admiralty Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1067°F - 3 hrs. - 0.144mm. G.S. - R_F = 55, bar supplied - 3/4 inch diam. Bar sample - reduced section: 0.25 inch diam. X 1.5 inches long, clamp-on strain gage extensometer - 1 inch G.L., data spread = ± 5%.	71.4	27.6	1.0				1
316a	Annealed - 0.018mm. G.S., bar supplied - 0.125 inch diam.	71.1	28.0	0.90				316



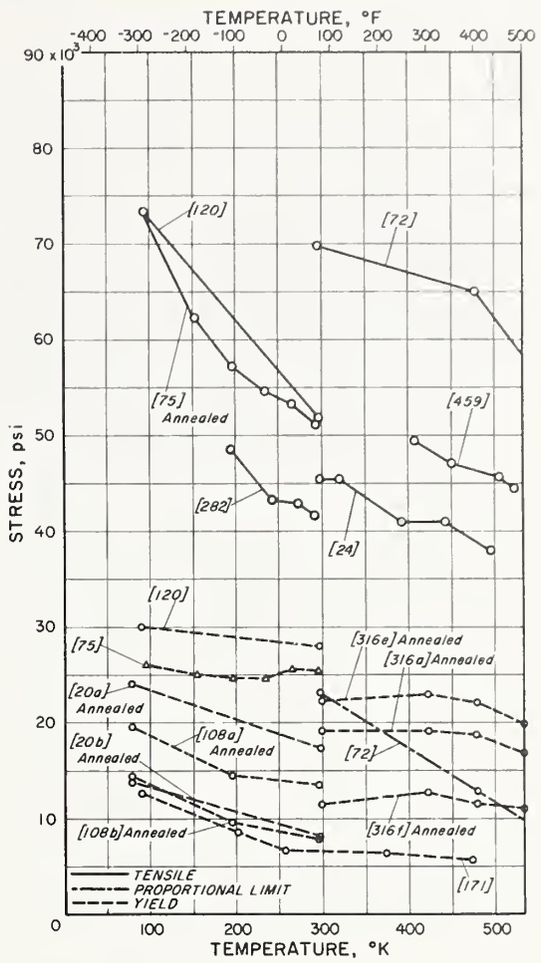
Modulus of Rigidity of 71Cu-28Zn-1Sn (Admiralty Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1c	Annealed 1000°F - 1/2 hr., bar supplied - 3/4 inch diam. Bar sample - reduced section: 2.5 inches long X 0.125 inch diam., shear modulus determined isothermally by applying weights, maximum shear stress of 350 psi, data spread = ± 2%.	71.4	27.6	1.0				1

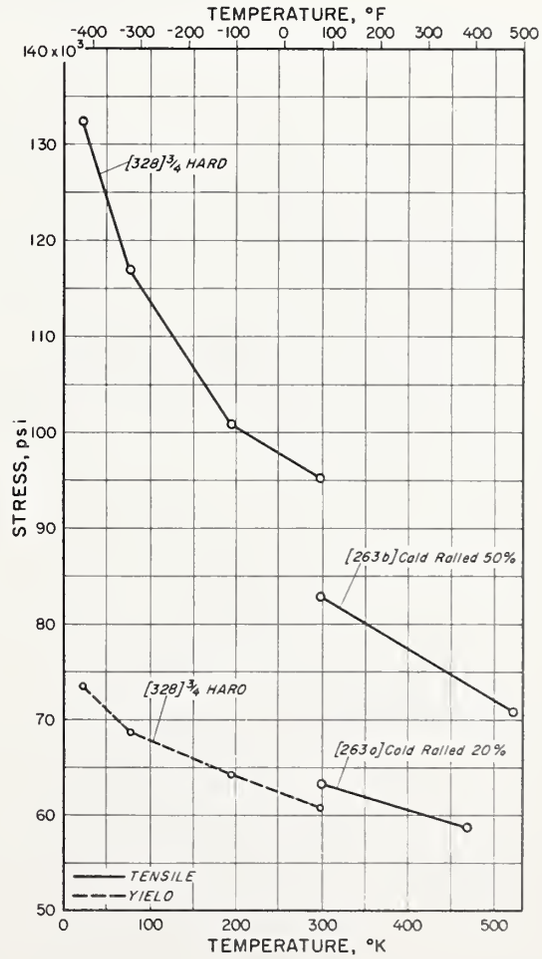


Tensile and Yield Strength of 70Cu-30Zn (Cartridge Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
20a	Annealed - 0.016mm. G.S. - after hot reducing 75% and cold rolling 40%. Bar sample - 1/4 inch diam., strain rate = 0.0028 inch/inch/minute.	69.5	30.5					20
20b	Annealed - 0.113mm. G.S. Other specifications same as 20a.	69.5	30.5					20
24	Wrought.	72	28					24
72		69.5	30.4					72
75	Annealed - after rolling, bar supplied - 1 inch diam. Bar sample - 0.25 inch diam.	69.5	30.5					75
108a	Annealed 1112°F in vacuum - air cooled - 0.03mm. G.S. Bar sample - 0.0788 inch diam., strain rate ≈0.0001 inch/inch/sec., Y.S. - 0.5% strain.	70	30					108
108b	Annealed 1472°F in vacuum - air cooled - 0.045mm. G.S. Bar sample - 0.0788 inch diam., strain rate ≈0.0001 inch/inch/sec., Y.S. - 0.5% strain.	70	30					108
120	Bar sample - 0.25 inch diam.	69.4	30.5				0.1Fe	120
171	Greater than 0.024mm. G.S.	71.5	28.5					171
282	Annealed 1292°F - 1/2 hr., bar supplied - 5/8 inch diam. Bar sample - 0.394 inch diam.	71.6	28.4					282
316a	Annealed - 0.022mm. G.S. Bar sample - 0.125 inch diam., Y.S. - 0.5% strain.	70.5	29.5					316
316e	Annealed - 0.016mm. G.S. Bar sample - 0.125 inch diam., Y.S. - 0.5% strain.	69.4	30.6					316
316f	Annealed - 0.085mm. G.S. Bar sample - 0.125 inch diam., Y.S. - 0.5% strain.	69.4	30.6					316
459	Wire sample, constant load applied while wire was heated at 36°F/minute until sample broke.	70.8	29.2					459

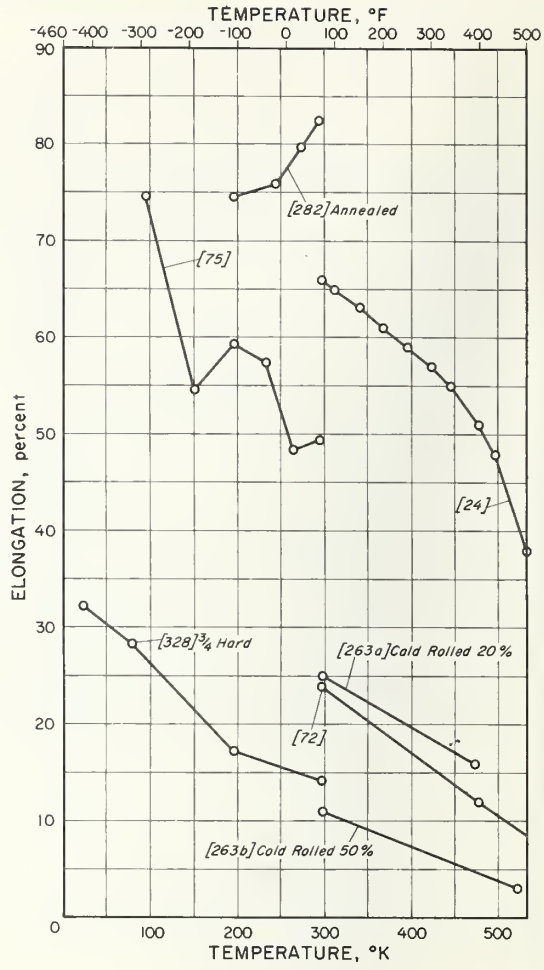


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
263a	Cold rolled 20%. Bar sample - 0.505 inch diam., crosshead speed ≈0.25 inch/minute.	68.0	32.0					263
263b	Cold rolled 50%. Bar sample - 0.505 inch diam., crosshead speed ≈0.25 inch/minute.	67.6	32.3				0.1Pb	263
328	3/4 hard - ASTM G.S. # = 8.5 - R_B = 88, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.25 inches long X 0.177 inch reduced diam., crosshead speed = 0.02 inch/minute except for 1 test at room temp.: 0.05 inch/minute, Y.S. - 0.2% offset.	70.3	29.6					328



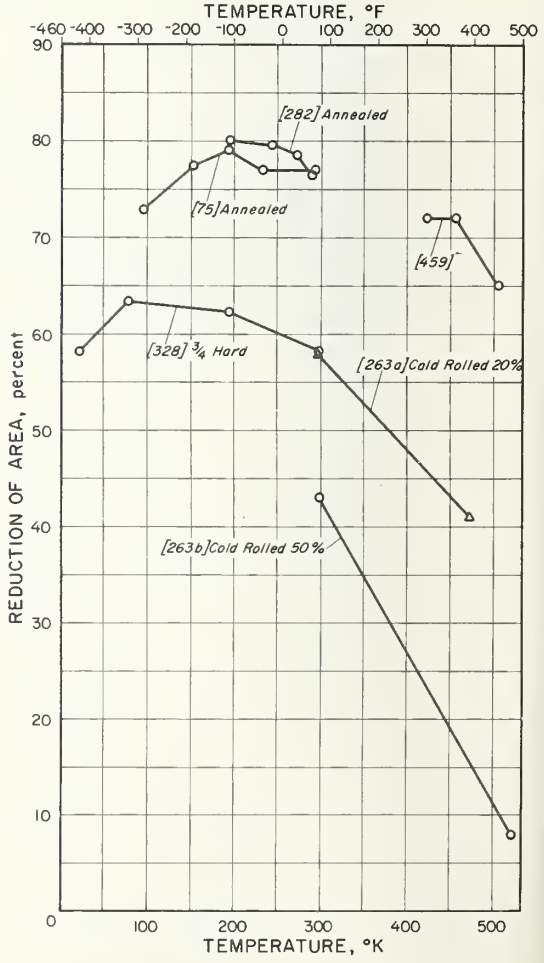
Tensile Elongation of 70Cu-30Zn (Cartridge Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
24	Wrought.	72	28					24
72		69.5	30.4					72
75	Annealed - after rolling, bar supplied - 1 inch diam. Bar sample - 0.25 inch diam.	69.5	30.5					75
263a	Cold rolled 20%. Bar sample - 0.505 inch diam., crosshead speed ≈0.25 inch/minute, 2 inch G.L.	68.0	32.0					263
263b	Cold rolled 50%. Bar sample - 0.505 inch diam., crosshead speed ≈0.25 inch/minute, 2 inch G.L.	67.6	32.3				0.1Pb	263
282	Annealed 1292°F - 1/2 hr., bar supplied - 5/8 inch diam. Bar sample - 0.394 inch diam., 2 inch G.L.	71.6	28.4					282
328	3/4 hard - ASTM G.S.# = 8.5 - R_B = 88, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1-1/4 inch long X 0.177 inch reduced diam., crosshead speed = 0.02 inch/minute, except for 1 test at room temp.: 0.05 inch/minute, 0.708 inch G.L. (4 X diam.).	70.3	29.6					328



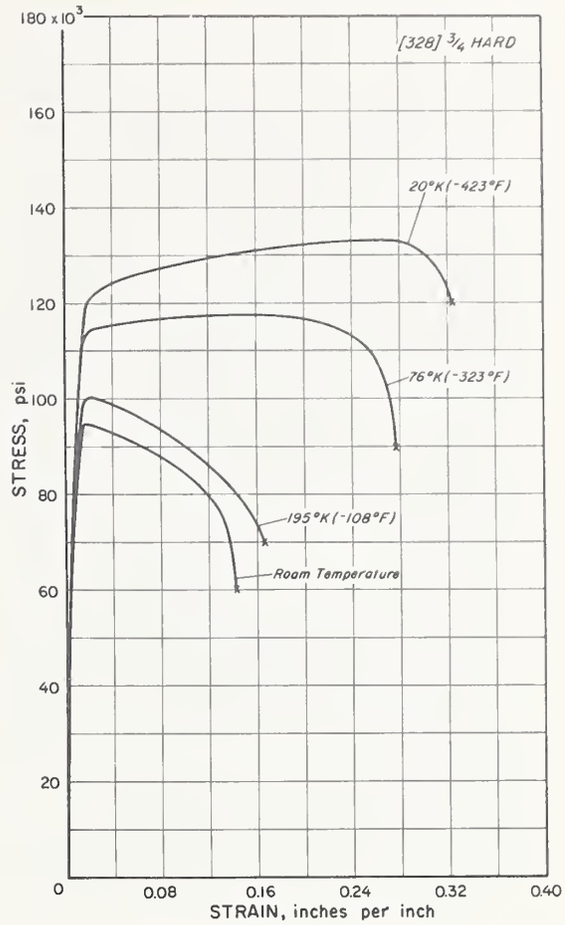
Tensile Reduction of Area of 70Cu-30Zn (Cartridge Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
75	Annealed - after hot rolling, bar supplied - 1 inch diam. Bar sample - 0.25 inch diam.	69.5	30.5					75
263a	Cold rolled 20%. Bar sample - 0.505 inch diam., crosshead speed = 0.25 inch/minute.	68.0	32.0					263
263b	Cold rolled 50%. Bar sample - 0.505 inch diam., crosshead speed = 0.25 inch/minute.	67.6	32.3				0.1Pb	263
282	Annealed 1292°F - 1/2 hr., bar supplied - 5/8 inch diam. Bar sample - 0.394 inch diam.	71.6	28.4					282
328	3/4 hard - ASTM G.S.# = 8.5 - R_B = 88, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1-1/4 inch long X 0.177 inch reduced diam., crosshead speed = 0.02 inch/minute except for 1 test at room temp.: 0.05 inch/minute.	70.3	29.6					328
459	Wire sample, constant load applied while wire was heated at 36°F/minute until sample broke.	70.8	29.2					459



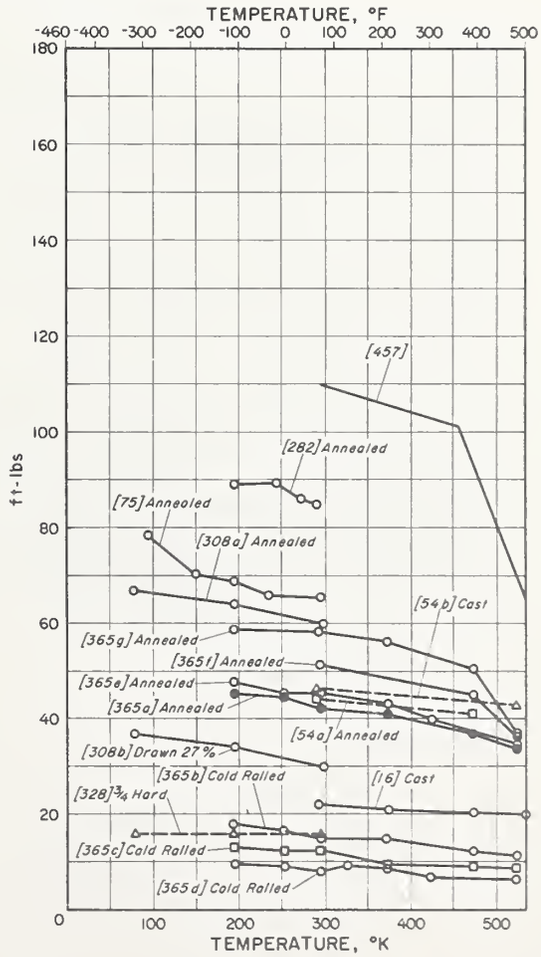
Tensile Stress-Strain Curves of 70Cu-30Zn (Cartridge Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
328	3/4 hard - ASTM G.S.# = 8.5 - R_B = 88, bar supplied - 3/4 inch diam. Bar sample - reduced section 1-1/4 inch long X 0.177 inch reduced diam., crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer - 1 inch G.L.	70.3	29.6					328



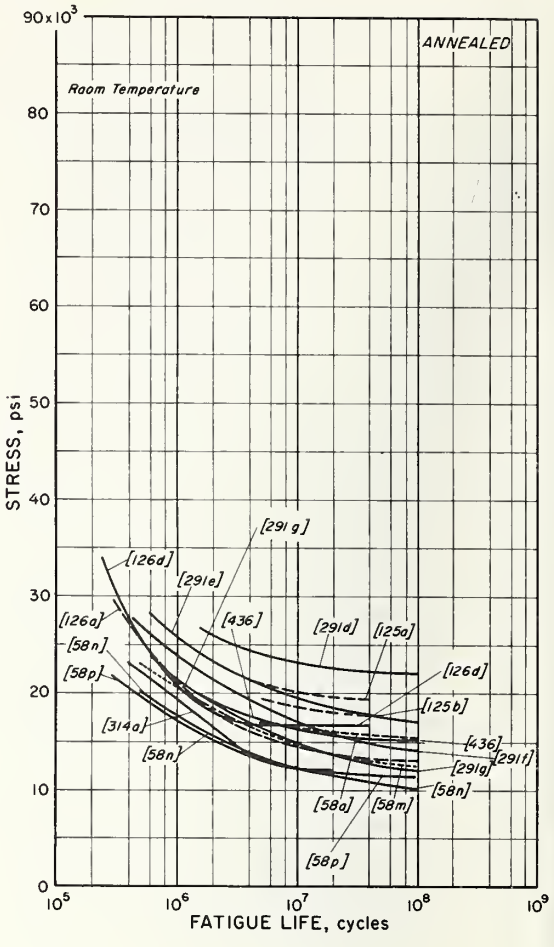
Impact Energy of 70Cu-30Zn (Cartridge Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
16	Sand cast - 2 to 4mm G.S. Sample - 5/16 inch diam. - notched - simple beam, no fracture - all temps.	72.0	28.0					16
54a	Annealed 1292°F - 4 hrs., bar supplied - 1/2 inch square. Izod, samples did not fracture completely: bent 65°, temperature accuracy = ± 2°F.	70	30					54
54b	Chill - cast. Other specifications same as 54a.	70	30					54
75	Annealed - after rolling, bar supplied - 1 inch diam. Izod.	69.5	30.5					75
282	Annealed 1292°F - 1/2 hr. V-notch sample - 0.394 X 0.394 X 3.94 inches.	71.6	28.4					282
308a	Annealed. Charpy keyhole.	70	30					308
308b	Drawn 27%. Charpy keyhole.	70	30					308
328	3/4 hard-ASTM G.S.# = 8.5 - R_B = 88, bar supplied - 3/4 inch diam. Charpy V notch, samples completely fractured.	70.3	29.6					328
365a	Annealed 1202°F - Brinell hardness = 62. Sample ASTM standard Charpy V except for length: 2.36 inches, tested longitudinally, 75 to 212°F - tested in water; 212 to 482°F - tested in oil bath.	70.0	30.0					365
365b	Cold rolled. Tested longitudinally. Other specifications same as 365a.	70.0	30.0					365
365c	Cold rolled. Tested transversely. Other specifications same as 365a.	70.0	30.0					365
365d	Cold rolled - Brinell hardness = 170. Tested transversely. Other specifications same as 365a.	70.1	29.9					365
365e	Annealed. Other specifications same as 365a.	70.1	29.8					365
365f	Annealed. Other specifications same as 365a.	69.4	30.4				0.1Fe, 0.1Pb	365
365g	Annealed. Other specifications same as 365a.	69.2	30.3				0.5Pb	365
457	Assumed type sample - Mesnager: U-notch - 0.079 inch deep X 0.079 inch wide; cross section - 0.394 X 0.394 inch, point data not presented by author.	70.3	28.3					457

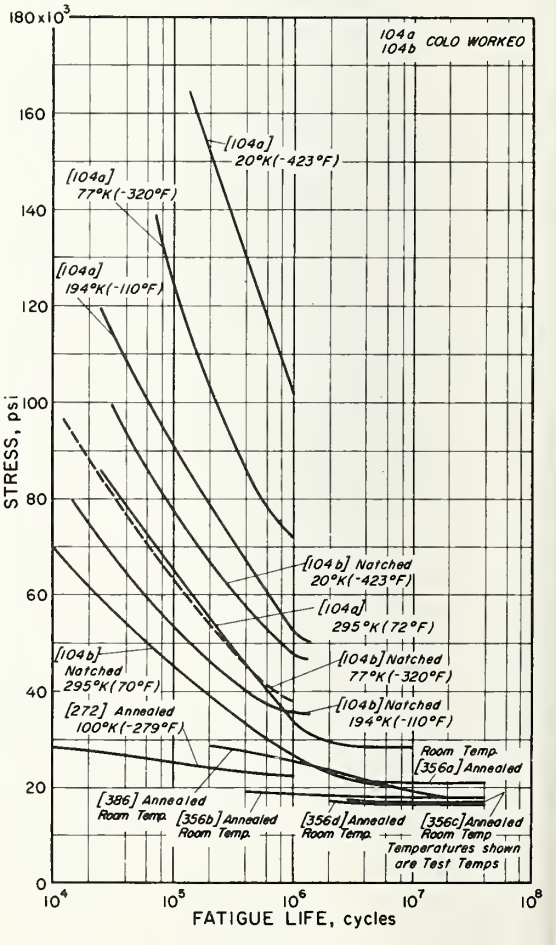


Fatigue Behavior of 70Cu-30Zn (Cartridge Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
58m	Annealed - 0.030mm. G.S., room temp.: U.T.S. = 49,500 psi., sheet supplied - 0.032 inch thick. Sheet sample - tapered - 5-1/2 inches long X 3/8 inch wide, tested in rolling direction, flexure cantilever - 900 c.p.m.	69.9	30.1					58
58n	Annealed - 0.10mm. G.S., room temp.: U.T.S. = 45,000 psi. Other specifications same as 58m.	69.9	30.1					58
58o	Annealed - 0.025mm. G.S., room temp.: U.T.S. = 49,000 psi. Other specifications same as 58m.	69.9	30.1					58
58p	Annealed - 0.120mm. G.S., room temp.: U.T.S. = 45, 000 psi. Other specifications same as 58m.	69.9	30.1					58
125a	Annealed. Bar sample - 0.25 inch diam., uniaxial stress - 2200 c.p.m., R = -1, tested in dry nitrogen.	69.9	30.1					125
125b	Tested in damp nitrogen - 55% relative humidity, sample at 17,700 psi - 5×10^7 cycles did not break. Other specifications same as 125a.	69.9	30.1					125
126a	Annealed 1112°F, room temp.: U.T.S. = 46,300 psi, sheet supplied - 0.020 inch thick. Sheet sample - tapered - 5-1/2 inches long X 3/8 inch wide, tested in rolling direction, flexure cantilever - 750 c.p.m.	71.7	28.3					126
126d	Annealed 1112°F, room temp.: U.T.S. = 49,400 psi. Other specifications same as 126a.	71.7	28.3					126
291d	Annealed 750°F - 4 hrs. - 0.012mm. G.S., room temp.: U.T.S. = 60,000 psi. Bar sample - 1-3/4 inch long X 0.15 inch reduced diam. - electropolished, rotating cantilever - 8000 to 1000 r.p.m., R = -1, sample at 22,000 psi - 1.1×10^8 cycles did not break.	69.5	30.4					291
291e	Annealed 960°F 4 hrs. - 0.026mm. G.S. - room temp.: U.T.S. = 51,500 psi - sample at 17,000 psi - 1.1×10^8 cycles did not break. Other specifications same as 291d.	69.5	30.4					291
291f	Annealed 1050°F - 4 hrs. - 0.051mm. G.S. Sample at 14,000 psi - 9×10^7 cycles did not break. Other specifications same as 291d.	69.5	30.4					291
291g	Annealed 1200°F - 4 hrs. - 0.131mm. G.S. Other specifications same as 291d.	69.5	30.4					291
314a	Annealed 1112°F - R_B = 16, room temp.: U.T.S. = 46,300 psi. Sheet sample - 3-9/32 inches long - width reduced from 15/32 to 3/16 inch - uniform cross section part: 2-3/16 inches long X 0.020 inch thick, cut parallel to rolling direction, rotating cantilever machine - 1500 r.p.m., R = -1.	71.7	28.2					314
436	Annealed, room temp.: U.T.S. = 45,000 psi - Y.S. = 9,800 psi. Rotating cantilever, sample at 15,000 psi - 10^8 cycles did not break.	70.0	29.9				0.1Fe	436

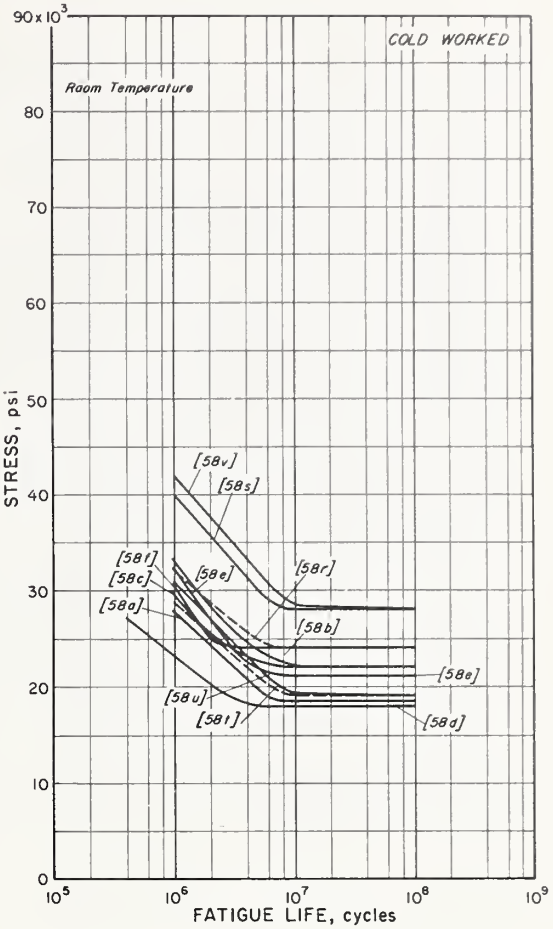


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
104a	Heated 400°F - 1 hr. - Vickers hardness = 191 (5 kgm. load) - after receiving in spring temper, room temp.: U.T.S. = 95,000 psi - Y.S. = 88,000 psi (0.2% offset). Sheet sample - 0.040 inch thick, flexure test - 1800 c.p.m., R = -1, sample at 27,000 psi - 10^7 cycles did not break.	70.4	29.3	–	–		0.1Fe	104
104b	Notched sample - K_T = 3.2, 1725 c.p.m., sample at 46,000 psi - 1.2×10^8 cycles did not break. Other specifications same as 104a.	70.4	29.3				0.1Fe	104
272	Annealed 932°F - Ar atmos. - 1 hr. - 0.030mm. G.S. Bar sample - round - electropolished, 3600 r.p.m., R = -1.	70	30					272
356a	Annealed. Bar sample - 0.25 inch reduced diam., 2200 c.p.m. tested in vacuum of 0.0005 to 0.001mm. Hg. Samples at 20,600 psi - 3.2×10^7 cycles and 20,200 psi - 3.5×10^7 cycles did not break, tensile fatigue.							356
356b	Tested in dry purified air, samples at 17,500 and 17,000 psi - 3.3×10^7 cycles and 17,700 psi - 4.2×10^7 cycles did not break. Other specifications same as 356a.							356
356c	Tested in air, samples at 16,800 psi - 3.2×10^7 and 3.8×10^7 cycles and 16,300 psi - 3×10^7 cycles did not break. Other specifications same as 356a.							356
356d	Tested in damp purified air about 55% relative humidity - Sample at 16,600 psi - 3×10^7 cycles did not break. Other specifications same as 356a.							356
386	Annealed 550°C - 2 hrs. - after cold drawing 30%, room temp.: U.T.S. = 46,500 psi - Y.S. = 13,800 psi (0.2% offset) - R_F = 61. Bar sample - 0.665 inch diam.	69.9	30.1					386

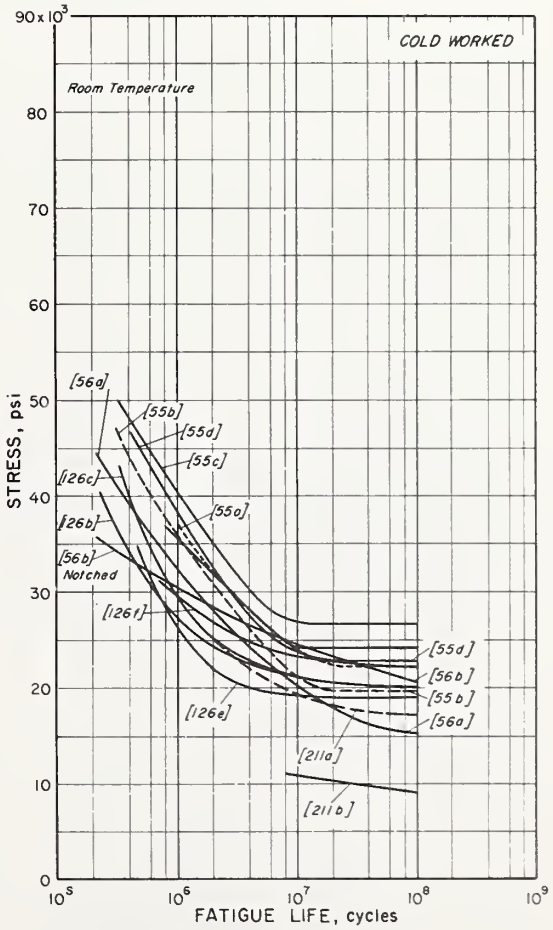


Fatigue Behavior of 70Cu-30Zn (Cartridge Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
58a	Rolled 21% - 0.025mm. G.S., room temp.: U.T.S. = 63,400 psi - Y.S. = 52,000 psi (0.5% strain), sheet supplied - 0.032 inch thick. Sheet sample - tapered - 5-1/2 inches long X 3/8 inch wide, tested in rolling direction, flexure cantilever - 900 c.p.m.	69.9	30.1					58
58b	Rolled 37% - 0.035mm. G.S., room temp.: U.T.S. = 76,500 psi. Other specifications same as 58a.	69.9	30.1					58
58c	Rolled 60% - 0.025mm. G.S., room temp.: U.T.S. = 92,500 psi. Other specifications same as 58a.	69.9	30.1					58
58d	Rolled 21% - 0.080mm. G.S., room temp.: U.T.S. = 62,000 psi. Other specifications same as 58a.	69.9	30.1					58
58e	Rolled 37% - 0.075mm. G.S., room temp.: U.T.S. = 71,500 psi - Y.S. = 59,900 psi (0.5% strain). Other specifications same as 58a.	69.9	30.1					58
58f	Rolled 60% - 0.075mm. G.S., room temp.: U.T.S. = 92,000 psi - Y.S. = 66,400 psi (0.5% strain). Other specifications same as 58a.	69.9	30.1					58
58r	Rolled 37% - 0.035mm. G.S., room temp.: U.T.S. = 80,500 psi - Y.S. = 62,800 psi (0.5% strain). Tested 90° to rolling direction. Other specifications same as 58a.	69.9	30.1					58
58s	Rolled 60% - 0.025mm. G.S., room temp.: U.T.S. = 101,000 psi. Tested 90° to rolling direction. Other specifications same as 58a.	69.9	30.1					58
58t	Rolled 21% - 0.080mm. G.S., room temp.: U.T.S. = 61,000 psi. Tested 90° to rolling direction. Other specifications same as 58a.	69.9	30.1					58
58u	Rolled 37% - 0.075mm. G.S., room temp.: U.T.S. = 75,500 psi. Tested 90° to rolling direction. Other specifications same as 58a.	69.9	30.1					58
58v	Rolled 60% - 0.075mm. G.S., room temp.: U.T.S. = 69,900 psi (0.5% strain). Tested 90° to rolling direction. Other specifications same as 58a.	69.9	30.1					58

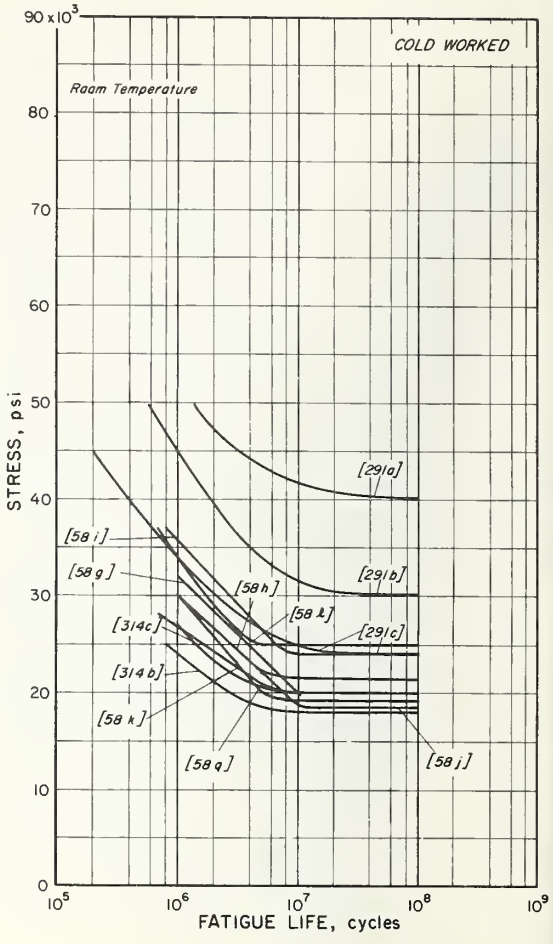


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
55a	Drawn 84%, room temp.: U.T.S. = 120,000 psi - Y.S. = 85,500 psi (0.2% offset). Wire sample - 0.072 inch diam., rotating arc - 3450 r.p.m., R = -1. Samples at 20,000 - 21,500 - 22,000 psi - 10^8 cycles did not break.	69.3	30.7					55
55b	Drawn 60%, room temp.: U.T.S. = 98,500 psi - Y.S. = 66,500 psi (0.2% offset). Wire sample - 0.072 inch diam., rotating arc - 3450 r.p.m., R = -1.	69.3	30.7					55
55c	Drawn 84%, room temp.: U.T.S. = 133,000 psi - Y.S. = 92,000 psi (0.2% offset). Wire sample - 0.072 inch diam., rotating arc - 3450 r.p.m., R = -1.	71.4	27.7	0.9				55
55d	Drawn 60%, room temp.: U.T.S. = 106,500 psi - Y.S. = 80,500 psi (0.2% offset). Wire sample - 0.072 inch diam., rotating arc - 3450 r.p.m., R = -1.	71.4	27.7	0.9				55
56a	Drawn 21% - 0.120mm. G.S., room temp.: U.T.S. = 57,000 psi - Y.S. = 45,500 psi (0.2% offset), bar supplied - 0.625 incb diam. Bar sample - 0.30 inch reduced diam., rotating cantilever - 8000 r.p.m.	69.4	30.6					56
56b	Notched sample - 0.350 inch diam. at notch - 0.0025 inch notch radius (K_T = 8.35), 60°. Other specifications same as 56a.	69.4	30.6					56
126b	Rolled 37.1%, room temp.: U.T.S. = 81,600 psi, sheet supplied - 0.020 inch thick. Sheet sample - tapered - 5-1/2 inches long X 3/8 inch wide, tested in rolling direction, flexure cantilever - 750 c.p.m.	71.7	28.3					126
126c	Rolled 68.7%, room temp.: U.T.S. = 97,800 psi. Other specifications same as 126b.	71.7	28.3					126
126e	Rolled 37.1%, room temp.: U.T.S. = 75,200 psi. Other specifications same as 126b.							126
126f	Rolled 60.5%, room temp.: U.T.S. = 93,800 psi. Other specifications same as 126b.							126
211a	Cold drawn, room temp.: U.T.S. = 50,400 psi. Bar sample, rotating cantilever - 1800 r.p.m., R = -1, data spread ± 5%.	73.2	26.6				0.1Fe, <0.1Pb	211
211b	Cold rolled, room temp.: U.T.S. = 47,800 psi. Alternating torsion - 240 c.p.m., R = -1, data spread = ± 10%.	71.6	28.2				0.1Fe, <0.1Pb	211



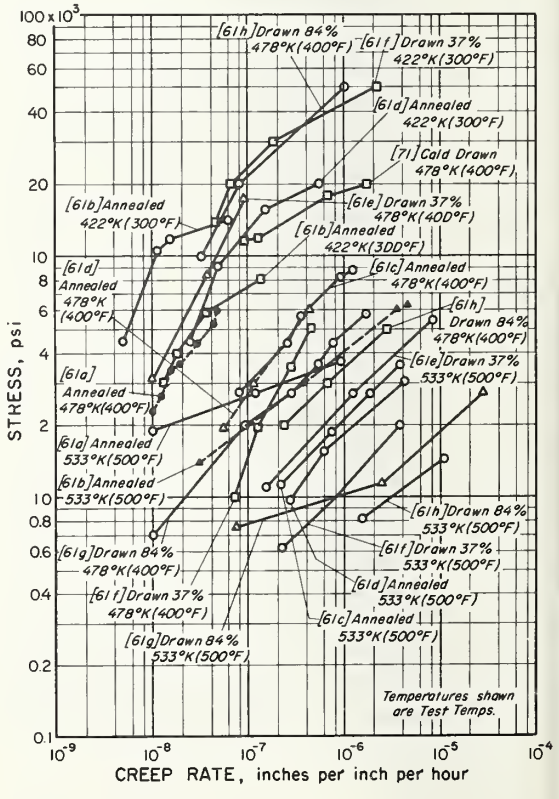
Fatigue Behavior of 70Cu-30Zn (Cartridge Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
58_g	Rolled 21% - 0.025mm. G.S., room temp.: U.T.S. = 61,300 psi - Y.S. = 51,700 psi (0.5% strain). Tested at 45° to rolling direction. Other specifications same as 58a.	69.9	30.1					58
58h	Rolled 37% - 0.035mm. G.S., room temp.: U.T.S. = 73,500 psi. Other specifications same as 58a.	69.9	30.1					58
58i	Rolled 60% - 0.025mm. G.S., room temp.: U.T.S. = 97,000 psi - Y.S. = 64,200 psi (0.5% strain). Other specifications same as 58a.	69.9	30.1					58
58j	Rolled 21% - 0.080mm. G.S., room temp.: U.T.S. = 58,000 psi. Other specifications same as 58a.	69.9	30.1					58
58k	Rolled 37% - 0.075mm. G.S., room temp.: U.T.S. = 71,000 psi - Y.S. = 58,200 psi (0.5% strain). Other specifications same as 58a.	69.9	30.1					58
58ℓ	Rolled 60% - 0.075mm. G.S., room temp.: U.T.S. = 94,500 psi - Y.S. = 66,400 psi (0.5% strain). Other specifications same as 58a.							58
58q	Rolled 21% - 0.025mm. G.S., room temp.: U.T.S. = 64,500 psi - Y.S. = 53,100 psi (0.5% strain). Tested 90° to rolling direction. Other specifications same as 58a.	69.9	30.1					58
291a	Cold drawn 60% - 0.015mm. G.S., room temp.: U.T.S. = 106,000 psi. Bar sample - 1-3/4 inch long X 0.15 inch reduced diam. - electropolished, rotating cantilever - 8000 to 10000 r.p.m., R = -1, sample at 40,000 psi - 1.1×10^8 cycles did not break.	69.5	30.4					291
291b	Cold drawn 40% - 0.015mm. G.S., room temp.: U.T.S. = 91,000 psi. Other specifications same as 291a.	69.5	30.4					291
291c	Cold drawn 20% - 0.015mm. G.S., room temp.: U.T.S. = 71,500 psi. Sample at 24,000 psi - 1.2×10^8 cycles did not break. Other specifications same as 291a.	69.5	30.4					291
314b	Rolled 37.1% - R_B = 84, room temp.: U.T.S. = 81,600 psi. Sheet sample - 3-9/32 inches long - width reduced from 15/32 to 3/16 inch - uniform cross section part: 2-3/16 inches long X 0.019 inch thick, cut parallel to rolling direction.	71.7	28.2					314
314c	Rolled 68.7% - R_B = 92, room temp.: U.T.S. = 97,800 psi. Other specifications same as 314b.							314



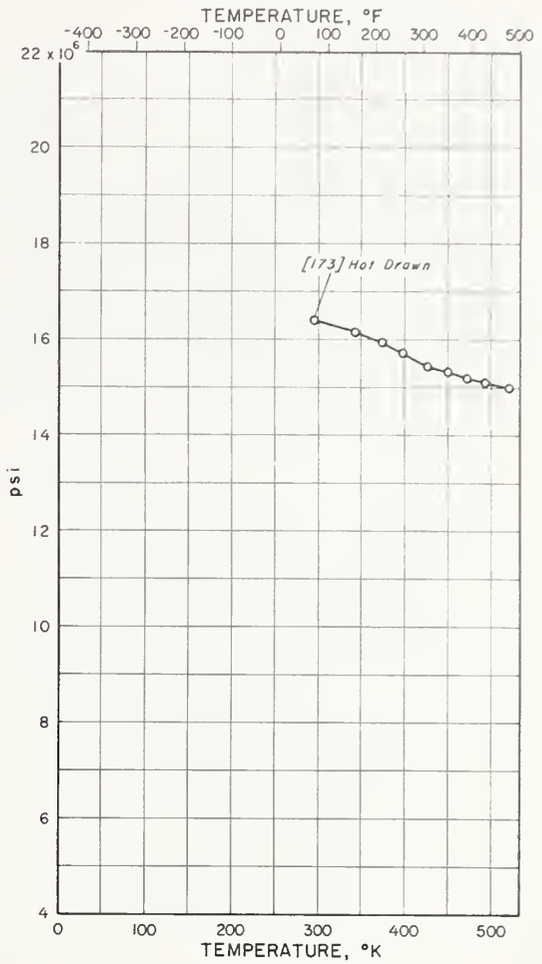
Creep Behavior of 70Cu-30Zn (Cartridge Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
61a	Annealed - 0.20mm. G.S., room temp.: U.T.S. = 42,500 psi - Y.S. = 8,500 psi (0.5% strain). Bar sample - 1/8 inch diam., 10 inch G.L.	70.5	29.5					61
61b	Annealed - 0.085mm. G.S., room temp.: U.T.S. = 48,500 psi - Y.S. = 11,500 psi (0.5% strain). Bar sample - 1/8 inch diam., 10 inch G.L.	69.4	30.6					61
61c	Annealed - 0.022mm. G.S., room temp.: U.T.S. = 52,000 psi - Y.S. = 19,000 psi (0.5% strain). Bar sample -1/8 inch diam., 10 inch G.L.	70.5	29.5					61
61d	Annealed - 0.016mm. G.S., room temp.: U.T.S. = 59,500 psi - Y.S. = 22,500 psi (0.5% strain). Bar sample - 1/8 inch diam., 10 inch G.L.	69.4	30.6					61
61e	Drawn 37% - "course grained", room temp.: U.T.S. = 85,000 psi. Bar sample - 1/8 inch diam., 10 inch G.L.	70.5	29.5					61
61f	Drawn 37% - "fine grained", room temp.: U.T.S. = 86,000 psi - Y.S. = 62,000 psi (0.5% strain). Bar sample - 1/8 inch diam., 10 inch G.L.	69.4	30.6					61
61_g	Drawn 84% - "course grained", room temp.: U.T.S. = 124, 500 psi. Bar sample - 1/8 inch diam., 10 inch G.L.	70.5	29.5					61
61h	Drawn 84% - "fine grained", room temp.: U.T.S. = 120,000 psi - Y.S. = 65,000 psi (0.5% strain). Bar sample - 1/8 inch diam., 10 inch G.L.	69.4	30.6					61
71	Cold drawn, bar supplied - 3/4 inch diam.	70.5	30.4					71



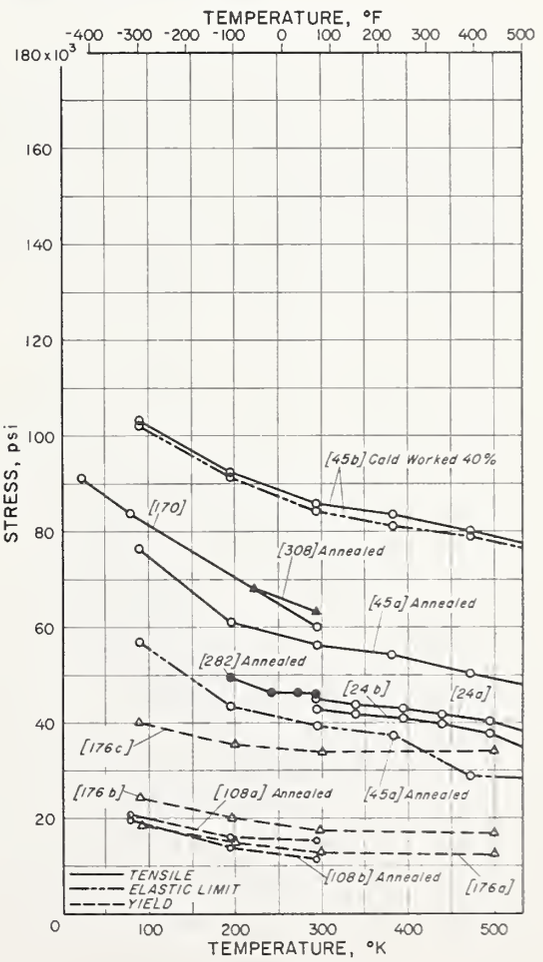
Modulus of Elasticity of 70Cu-30Zn (Cartridge Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
173	Hot drawn. Bar sample - 0.288 inch diam. X approx. 7 inches long, transverse vibrations.	72	28					173



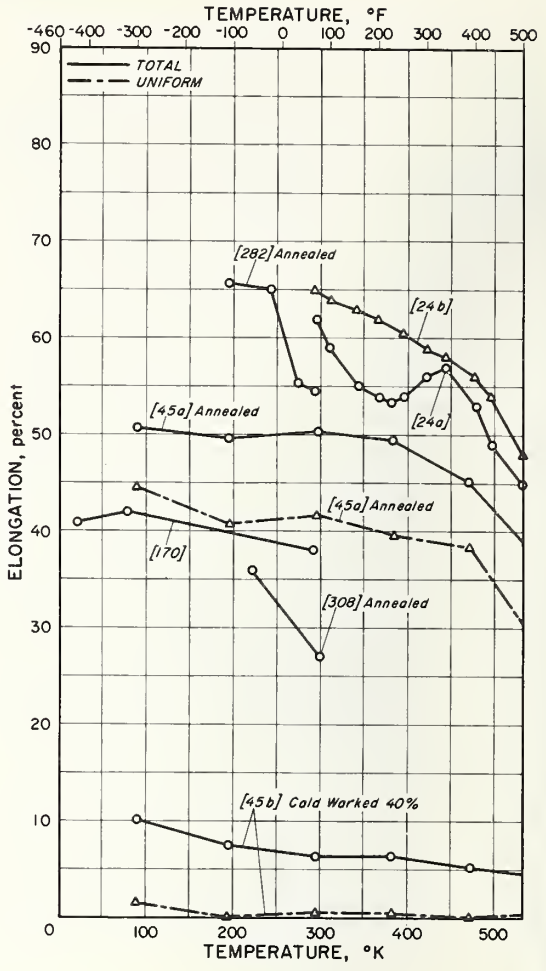
Tensile and Yield Strength of 65Cu-35Zn (Yellow Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
24a	Wrought.	65.0	35.0					24
24b	Wrought.	66.6	33.4					24
45a	Annealed 1020°F - 2 hrs. - in carbon dioxide. Bar sample - 0.197 inch diam.	67.0	33.0					45
45b	Cold worked 40%. Bar sample - 0.197 inch diam.	67.0	33.0					45
108a	Annealed 1112°F in vacuum - air cooled - 0.03mm. G.S. Bar sample - 0.0788 inch diam., strain rate ≈0.0001 inch/inch/sec., Y.S. - 0.5% strain.	90	10					108
108b	Annealed 1472°F in vacuum - air cooled - 0.045mm. G.S. Other specifications same as 108a.	90	10					108
170	Bar sample - 0.118 inch diam.	64.8	34.0				0.9Pb, 0.1Fe	170
176a	0.037mm. G.S.	63.6	36.4					176
176b	0.020mm. G.S.	63.6	36.4					176
176c	0.004mm. G.S.	63.6	36.4					176
282	Annealed 932°F - 1/2 hr., bar supplied - 5/8 inch diam. Bar sample - 0.394 inch diam.	63.8	35.7				0.4Pb, 0.1Fe	282
308	Annealed.	65.0	35.0					308



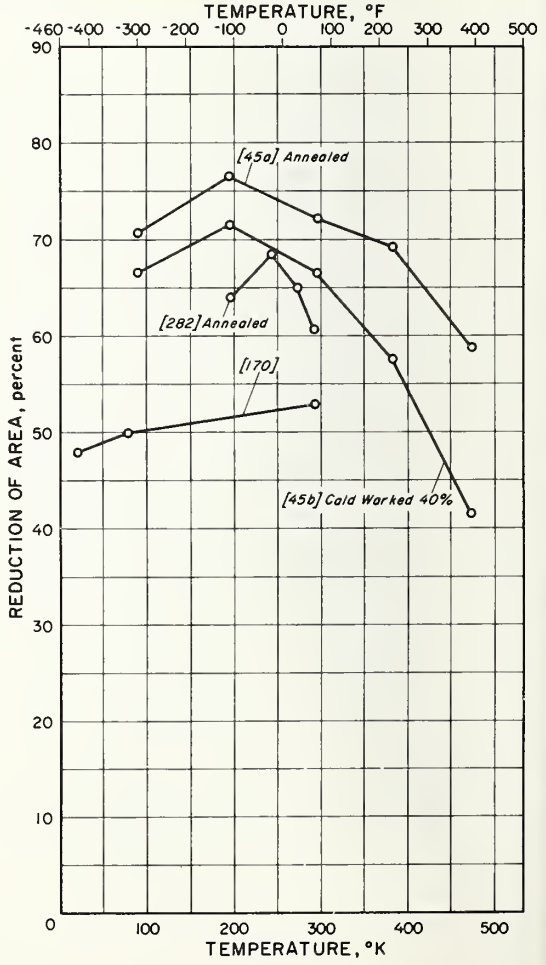
Tensile Elongation of 65Cu-35Zn (Yellow Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
24a	Wrought. 2 inch G. L.	65.0	35.0					24
24b	Wrought. 2 inch G. L.	66.6	33.4					24
45a	Annealed 1020°F - 2 hrs. - CO_2 atmos. Bar sample - 0.197 inch diam., 1.97 inch G. L. Lower curve denotes elongation prior to sample necking.	67.0	33.0					45
45b	Cold worked 40%. Bar sample - 0.197 inch diam., 1.97 inch G. L. Lower curve denotes elongation prior to sample necking.	67.0	33.0					45
170	Bar sample - 0.118 inch diam., 1.18 inch G. L.	64.8	34.0				0.9Pb, 0.1Fe	170
282	Annealed 932°F - 1/2 hr., bar supplied - 5/8 inch diam. Bar sample - 0.394 inch diam., 2 inch G. L.	63.8	35.7				0.4Pb, 0.1Fe	282
308	Annealed. 2 inch G. L.	65.0	35.0					308



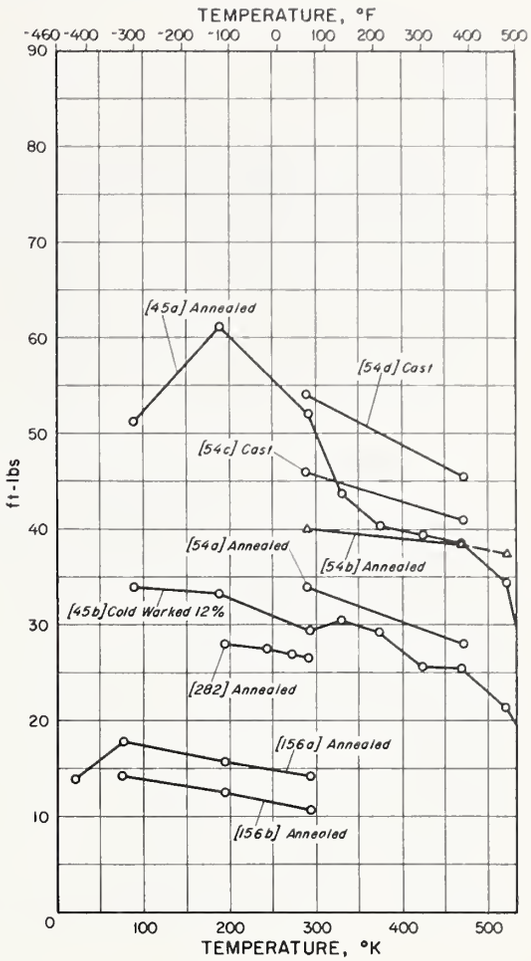
Tensile Reduction of Area of 70Cu-30Zn (Yellow Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
45a	Annealed 1020°F - 2 hrs. - CO_2 atmos. Bar sample - 0.197 inch diam.	67.0	33.0					45
45b	Cold worked 40%. Bar sample - 0.197 inch diam.	67.0	33.0					45
170	Bar sample - 0.118 inch diam.	64.8	34.0				0.9Pb, 0.1Fe	170
282	Annealed 932°F - 1/2 hr., bar supplied - 5/8 inch diam. Bar sample - 0.394 inch diam.	63.8	35.7				0.4Pb, 0.1Fe	282



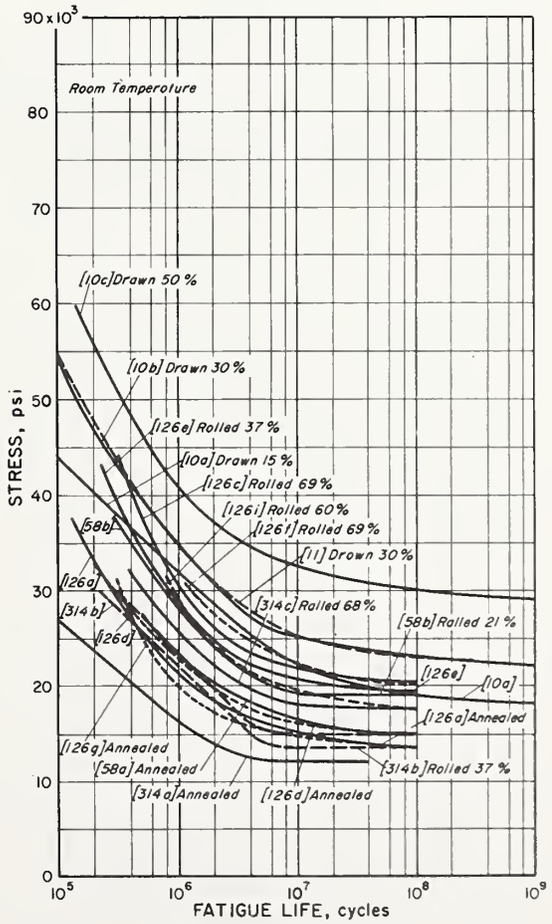
Impact Energy of 65Cu-35Zn (Yellow Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
45a	Annealed 1020°F - 2 hrs. - CO_2 atmos. Sample (Allemande type): V-notch - 45° - 3mm. deep - 8 X 10 X 100mm. cross-section.	67.0	33.0					45
45b	Cold worked 12%. Sample (Allemande type): V-notch - 45° - 3mm. deep - 8 X 10 X 100mm. cross-section.	67.0	33.0					45
54a	Annealed 1292°F - 4 hrs. - bar supplied - 1/2 inch square. Izod, samples did not fracture completely; bent 65° at 59°F and 60° at 392°F, temp. accuracy = ± 2°F.	64	36					54
54b	Same specifications as 54a.	65.7	34.3					54
54c	Chill - cast, bar supplied - 1/2 inch square. Izod, samples did not fracture completely; bent 65°, temp. accuracy = ± 2°F.	64	36					54
54d	Samples did not fracture completely; bent 70°. Other specifications same as 54c.	65.7	34.3					54
156a	Annealed, bar supplied - 1/2 inch square. Standard Charpy keyhole except for length: 2.0 inches, hammer velocity = 14.5 ft./sec. Sample contained in paper boat for -323 and -423°F tests - correction applied. 2 to 4 tests/temp.							156
156b	Soft. 1 to 4 tests/temp. Other specifications same as 156a.							156
282	Annealed 932°F - 1/2 hr. V-notch sample - 0.394 X 0.394 X 3.94 inches.	63.8	35.7				0.4Pb, 0.1Fe	282



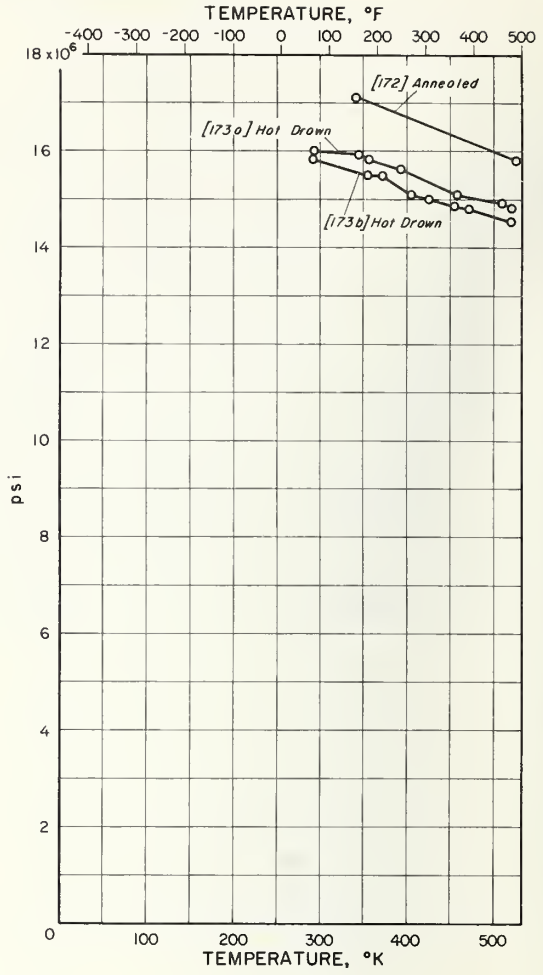
Fatigue Behavior of 65Cu-35Zn (Yellow Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
10a	Drawn 15.2% - 0.070mm. G.S., room temp.: U.T.S. = 57,200 psi - Y.S. = 43,100 psi (0.2% offset) - R_B = 71, bar - 1/2 inch diam. Bar sample - 0.3 inch reduced diam. - polished, rotating beam - 3500 r.p.m., R = -1, data spread = ± 5.5%.	63.0	37.0					10
10b	Drawn 30.1% - 0.060mm. G.S., room temp.: U.T.S. = 72,200 psi - Y.S. = 55,500 psi (0.2% offset) - R_B = 82. Data spread = 4.5%. Other specifications same as 10a.	63.0	37.0					10
10c	Drawn 50.1% - 0.040 to 0.050mm. G.S., room temp.: U.T.S. = 91,600 psi - Y.S. = 67,000 psi (0.2% offset) - R_B = 93. Data spread = ± 10%. Other specifications same as 10a.	63.0	37.0					10
11	Drawn 30.1% - 0.060mm. G.S., room temp.: U.T.S. = 72,200 psi - Y.S. = 53,900 psi (0.5% strain), bar supplied - 1/2 inch diam. Bar sample - 0.30 inch diam., rotating beam - 3500 r.p.m., data spread = ± 5%.	63.0	36.9					11
58a	Annealed - 0.030mm. G.S., room temp.: U.T.S. = 51,700 psi - Y.S. = 19,600 psi (0.2% offset), sheet - 0.032 inch thick. Tapered - 5-1/2 inches long, tested in rolling direction, flexure cantilever - 900 c.p.m.	65.2	34.7				0.1Pb	58
58b	Rolled 21% - 0.030mm. G.S., room temp.: U.T.S. = 64,800 psi - Y.S. = 52,500 psi (0.2% offset). Other specifications as 58a.	65.2	34.7				0.1Pb	58
126a	Annealed 1112°F. Sample - 0.020 inch thick, tapered - 5-1/2 inches long X 3/8 inch wide, tested in rolling direction, flexure cantilever - 750 c.p.m.	65.0	34.8				0.1Pb, 0.1Fe	126
126c	Rolled 68.7%, room temp.: U.T.S. = 93,900 psi. Other specifications same as 126a.	65.0	34.8				0.1Pb, 0.1Fe	126
126d	Annealed 1112°F, room temp.: U.T.S. = 46,600 psi. Other specifications same as 126a.	65.1	34.9					126
126e	Rolled 37.1%, room temp.: U.T.S. = 77,200 psi. Other specifications same as 126a.	65.1	34.9					126
126f	Rolled 68.7%, room temp.: U.T.S. = 95,600 psi. Other specifications same as 126a.	65.1	34.9					126
126g	Annealed 1112°F, room temp.: U.T.S. = 46,600 psi. Other specifications same as 126a.	64.8	35.2					126
126i	Rolled 60.5%, room temp.: U.T.S. = 91,900 psi. Other specifications same as 126a.	64.8	35.2					126
314a	Annealed 1112°F, room temp.: U.T.S. = 46,600 psi. Sheet sample - 2-3/16 inches long X 3/16 inch wide X 0.020 inch thick, parallel to rolling direction, rotating cantilever 1500 r.p.m., R = -1.	65.1	34.9					314
314b	Rolled 37.1%, room temp.: U.T.S. = 77,200 psi - R_B = 79. Sample 0.019 inch thick. Other same as 314a.	65.1	34.9					314
314c	Rolled 68.7%, room. temp.: U.T.S. = 95,600 psi - R_B = 87. Other specifications same as 314a.	65.1	34.9					314



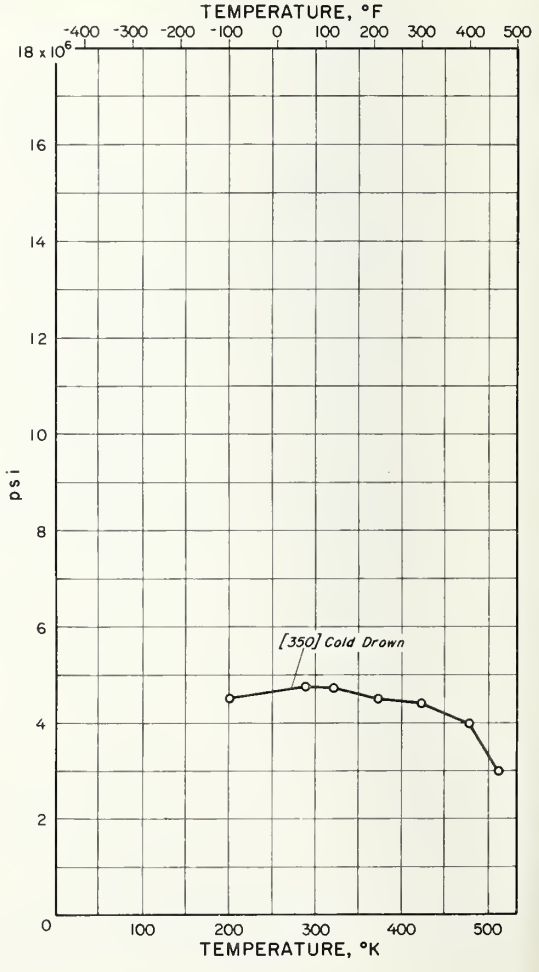
Modulus of Elasticity of 65Cu-35Zn (Yellow Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
172	Annealed 700°C - 2 hrs. Bar sample - 120 to 160mm. long X 5 to 9mm. diam., author does not present point data.	63.6	35.5				0.9Pb	172
173a	Hot drawn. Bar sample - 0.288 inch diam. X approx. 7 inches long, transverse vibrations.	67	33					173
173b	Hot drawn. Bar sample - 0.288 inch diam. X approx. 7 inches long, transverse vibrations.	63	37					173



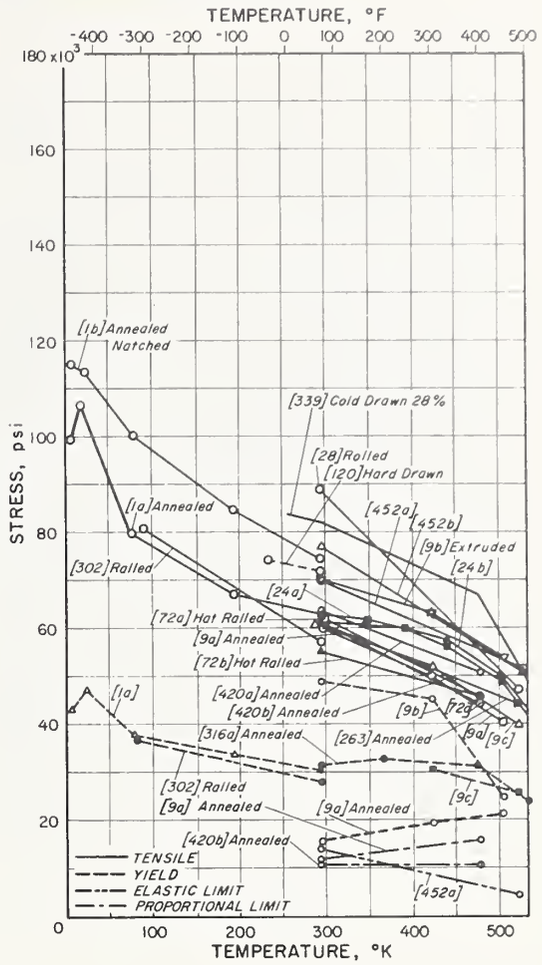
Modulus of Rigidity of 65Cu-35Zn (Yellow Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
350	Cold drawn - after annealing. Wire sample - 0.135 inch diam., isothermal shear modulus - determined by applying incrementals weights, 2 samples used - 6 determinations/ temp., absolute modulus error = ± 2%.	66.0	33.5					350



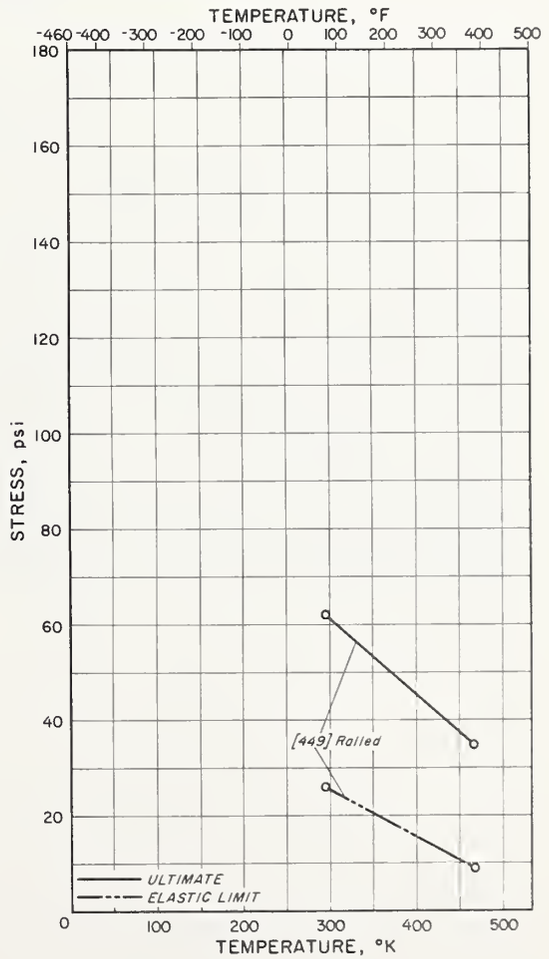
Tensile and Yield Strength of 60Cu-39Zn-1Sn (Naval Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1100°F - 1 hr. - 0.036mm. G.S. - R_B = 57, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, Y.S. - 0.2% offset.	59.6	39.7	0.6			0.1Pb	1
1b	Notched sample - 0.25 inch diam. at circumferential notch roots - 0.005 ± 0.0005 inch notch radius (K_T = 5.0). Other specifications same as 1a.	59.6	39.7	0.6			0.1Pb	1
9a	Annealed 1500°F - Brinell hardness = 96, bar supplied - 3/4 inch diam.	59.9	39.2	0.8				9
9b	Extruded - Brinell hardness = 145, bar supplied - 3/4 inch diam.	59.9	39.2	0.8				9
9c	Bar supplied - 5/8 inch diam.	59.8	38.7	0.3			1.0Pb, 0.2Fe	9
24a	Wrought.	60.0	39.2	0.8				24
24b	Wrought.	61.0	38.2	0.8				24
28	Rolled, bar supplied - 1/2 inch diam. Bar sample - 1/4 inch diam.	55.1	41.9	0.8	0.1	0.3	0.8Fe, 0.5Pb, 0.4Mn	28
72a	Hot rolled - 0.025mm. G.S., bar supplied - 3/4 inch diam.	58.8	40.4	0.8				72
72b	Hot rolled - 0.020mm. G.S., bar supplied - 3/4 inch diam.	60.2	39.7	0.1				72
120	Hard drawn. Y.S. - 0.2% offset.	62.6	37.0	0.3			0.1Pb	120
263	Annealed. Bar sample - 0.505 inch diam., crosshead speed ≈0.25 inch/minute.	60.1	39.1	0.8				263
302	Rolled.	61	38	1				302
316a	Annealed 1000°F. Bar sample - 0.125 inch diam., Y.S. - 0.2% offset.	60.0	39.4	0.6				316
339	Cold drawn 28% - R_B = 84. Plotted from continuous curve.	59.6	39.7	0.7				339
420a	Annealed - 0.025mm. G.S., bar supplied - 0.75 inch diam.	58.8	40.4	0.8				420
420b	Annealed - 0.045mm. G.S., bar supplied - 0.75 inch diam.	60.1	38.7	0.8				420
452a		59.0	39.8	0.6			0.6Pb	452
452b		56.9	40.3	0.8	0.2	0.2	0.7Fe, 0.7Pb, 0.2Mn	452



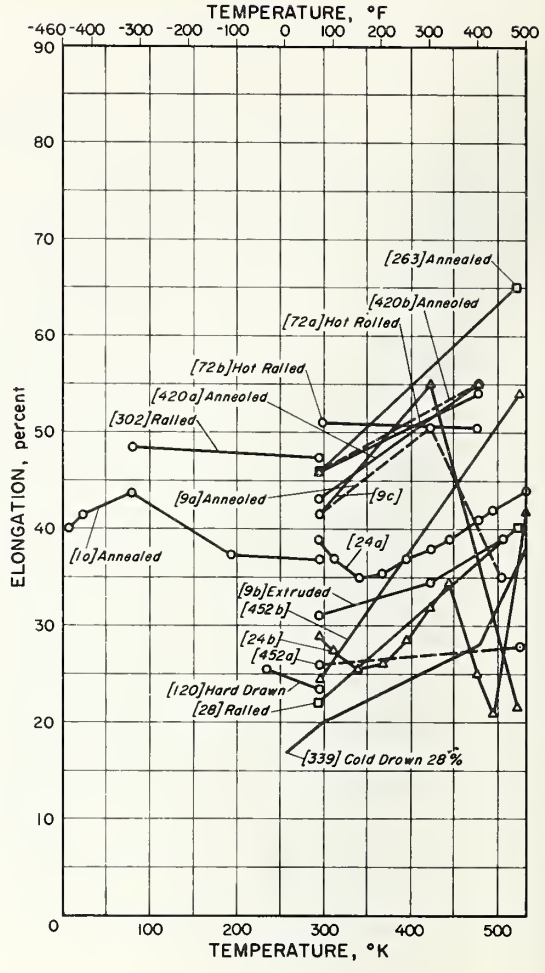
Shear Strength of 60Cu-39Zn-1Sn (Naval Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
449	Rolled. Bar sample - 0.855 inch diam., tested in torsion.	59.9	38.9	0.8			0.4Fe	449



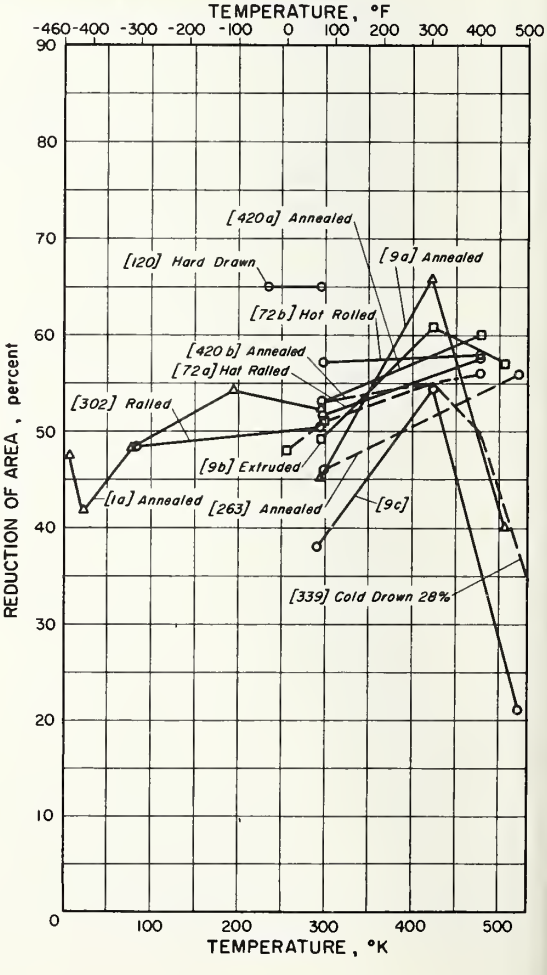
Tensile Elongation of 60Cu-39Zn-1Sn (Naval Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1100°F - 1 hr. - 0.036mm. G.S. - R_B = 57, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, 1 inch G.L.	59.6	39.7	0.6			0.1Pb	1
9a	Annealed 1500°F - Brinell hardness = 96, bar supplied - 3/4 inch diam. 2 inch G.L.	59.9	39.2	0.8				9
9b	Extruded - Brinell hardness = 145, bar supplied - 3/4 inch diam. 2 inch G.L.	59.9	39.2	0.8				9
9c	Bar supplied - 5/8 inch diam. 2 inch G.L.	59.8	38.7	0.3			1.0Pb, 0.2Fe	9
24a	Wrought. 2 inch G.L.	60.0	39.2	0.8				24
24b	Wrought. 2 inch G.L.	61.0	38.2	0.8				24
28	Rolled - bar supplied - 1/2 inch diam. Bar sample - 1/4 inch diam., 2 inch G.L.	55.1	41.9	0.8	0.1	0.3	0.8Fe, 0.5Pb, 0.4Mn	28
72a	Hot rolled - 0.025mm. G.S., bar supplied - 3/4 inch diam. 2 inch G.L.	58.8	40.4	0.8				72
72b	Hot rolled - 0.020mm. G.S., bar supplied - 3/4 inch diam. 2 inch G.L.	60.2	39.7	0.1				72
120	Hard drawn. 2 inch G.L.	62.6	37.0	0.3			0.1Pb	120
263	Annealed. Bar sample - 0.505 inch diam., crosshead speed ≈0.25 inch/minute, 2 inch G.L.	60.1	39.1	0.8				263
302	Rolled. 2 inch G.L.	61	38	1				302
339	Cold drawn 28% - R_B = 84. Plotted from continuous curve, 2 inch G.L.	59.6	39.7	0.7				339
420a	Annealed - 0.025mm. G.S., bar supplied - 0.75 inch diam. 2 inch G.L.	58.8	40.4	0.8				420
420b	Annealed - 0.045mm. G.S., bar supplied - 0.75 inch diam. 2 inch G.L.	60.1	38.7	0.8				420
452a	2 inch G.L.	59.0	39.8	0.6			0.6Pb	452
452b	2 inch G.L.	56.9	40.3	0.8	0.2	0.2	0.7Fe, 0.7Pb, 0.2Mn	452



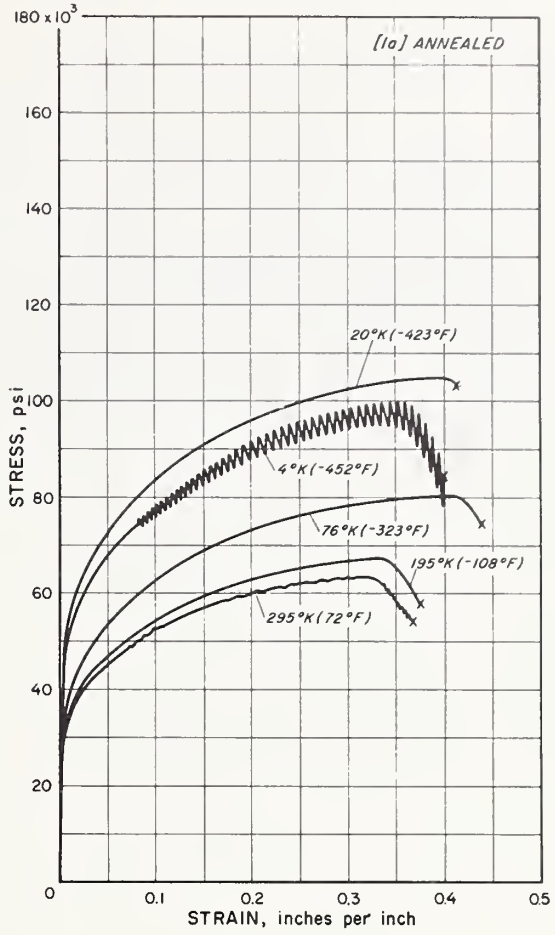
Tensile Reduction of Area of 60Cu-39Zn-1Sn (Naval Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1100°F - 1 hr. - 0.036mm. G.S. - R_B = 57, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute.	59.6	39.7	0.6			0.1Pb	1
9a	Annealed 1500°F - Brinell hardness = 96, bar supplied - 3/4 inch diam.	59.9	39.2	0.8				9
9b	Extruded - Brinell hardness = 145, bar supplied - 3/4 inch diam.	59.9	39.2	0.8				9
9c	Bar supplied - 5/8 inch diam.	59.8	38.7	0.3			1.0Pb, 0.2Fe	9
72a	Hot rolled - 0.025mm. G.S., bar supplied - 3/4 inch diam.	58.8	40.4	0.8				72
72b	Hot rolled - 0.020mm. G.S., bar supplied - 3/4 inch diam.	60.2	39.7	0.1				72
120	Hard drawn. Bar sample - 0.375 inch diam.	62.6	39.0	0.3			0.1Pb	120
263	Annealed. Bar sample - 0.505 inch diam., crosshead speed ≈0.25 inch/minute.	60.1	39.1	0.8				263
302	Rolled.	61	38	1				302
339	Cold drawn 28% - R_B = 84. Plotted from continuous curve.	59.6	39.7	0.7				339
420a	Annealed - 0.025mm. G.S., bar supplied - 0.75 inch diam.	58.8	40.4	0.8				420
420b	Annealed - 0.045mm. G.S., bar supplied - 0.75 inch diam.	60.1	38.7	0.8				420



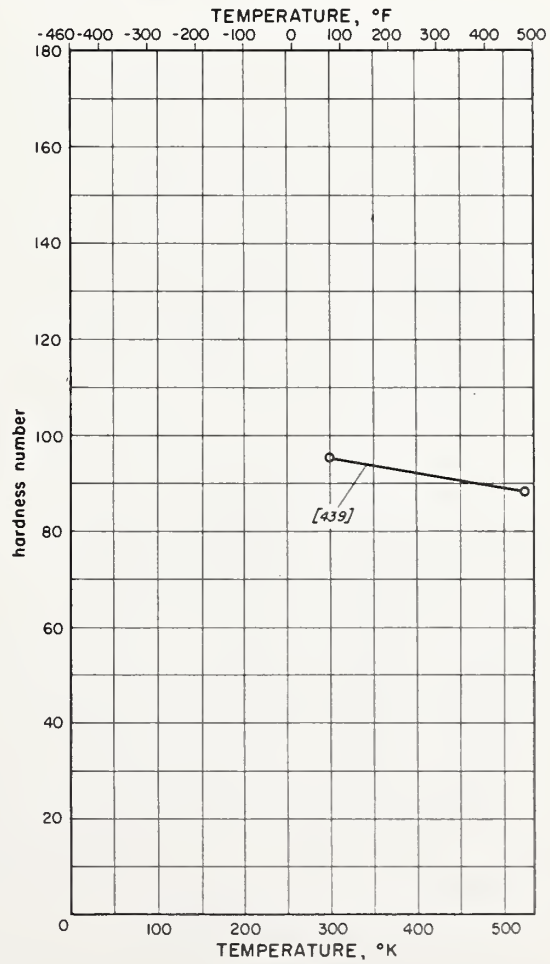
Tensile Stress-Strain Curves of 60Cu-39Zn-1Sn (Naval Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1100°F - 1 hr. - 0.036mm. G.S. - R_B = 57, bar supplied - 3/4 inch diam. Bar sample - 1.5 inch long reduced section X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer, 1 inch G.L.	59.6	39.7	0.6			0.1Pb	1



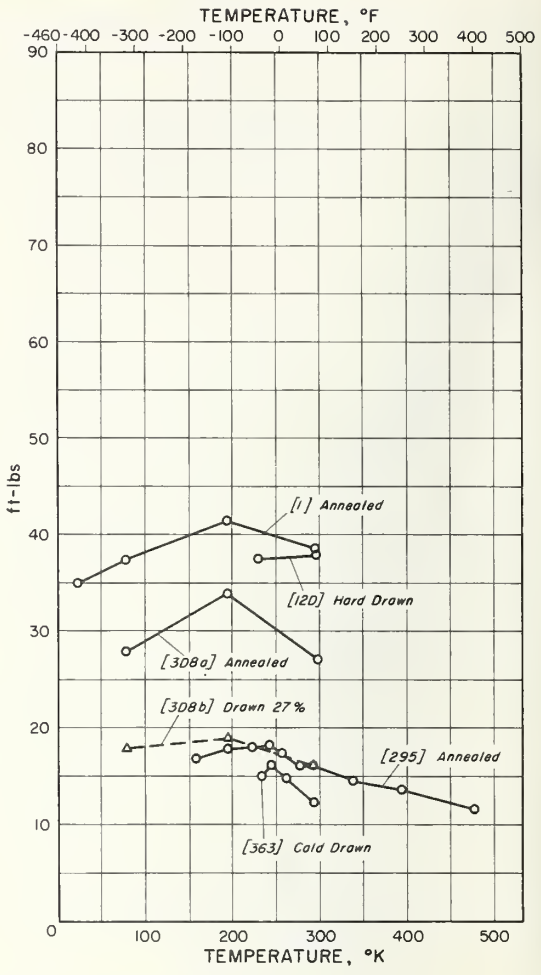
Hardness of 60Cu-39Zn-1Sn (Naval Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
439	Ball indenter - steel - 10mm. diam.							439



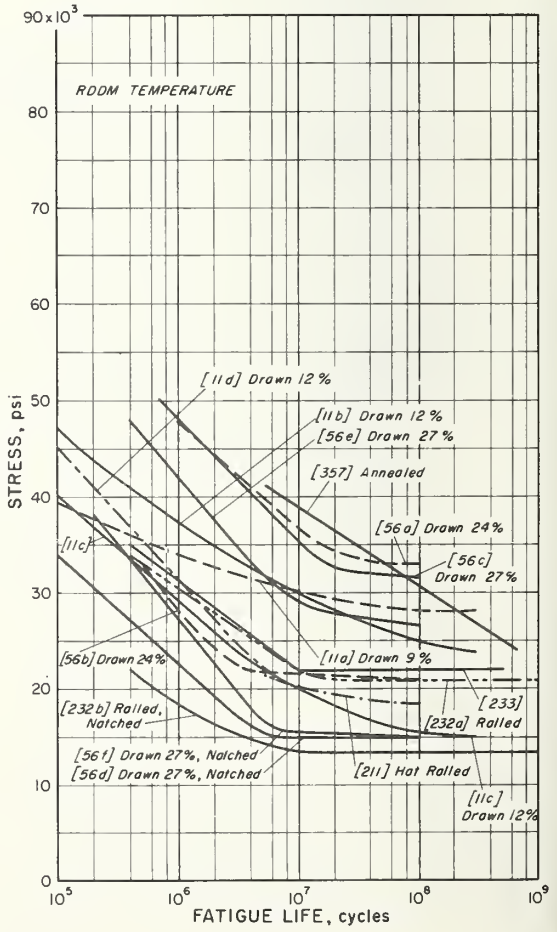
Impact Energy of 60Cu-39Zn-1Sn (Naval Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1	Annealed 1100°F - 1 hr. - 0.036mm. G.S. - R_B = 57, bar supplied - 3/4 inch diam. Charpy V-notch, 100% fracture - all temps., hammer velocity = 16 ft./sec., paper container glued to sample for -423°F tests.	59.6	39.7	0.6			0.1Pb	1
120	Hard drawn. Izod.	62.6	37.0	0.3			0.1Pb	120
295	Annealed - R_B = 61, bar supplied - 3/4 inch diam. Charpy keyhole, 100% fracture - all temps., 3 tests/temp., -175°F: ether and liquid air - other test temps. by warming from -175°F.	60.2	38.9	0.8			0.1Fe	295
308a	Annealed. Charpy keyhole.	60	39.2	0.8				308
308b	Drawn 27%. Charpy keyhole.	60	39.2	0.8				308
363	Cold drawn - Brinell hardness = 120 (500 kgm. load), bar supplied - 7/16 inch square. Standard Izod sample except for cross-section: 7/16 inch square, samples completely fractured, striking velocity = 11 ft./sec.							363



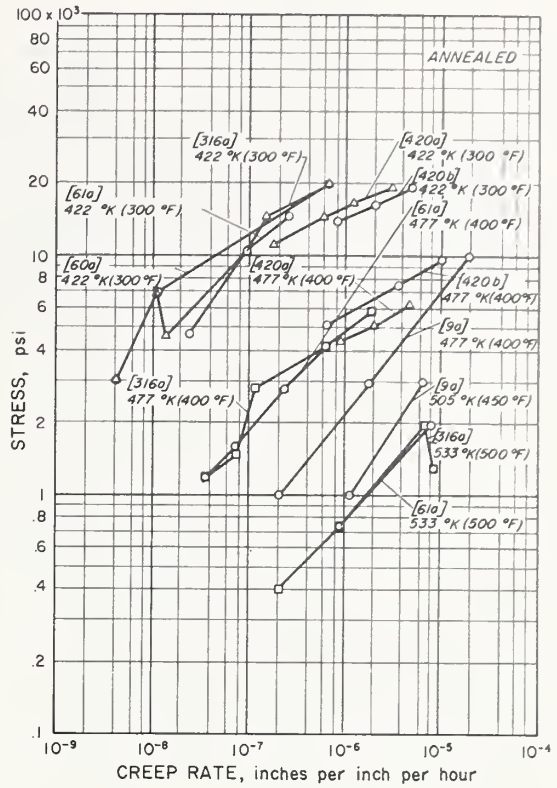
Fatigue Behavior of 60Cu-39Zn-1Sn (Naval Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
11a	Cold drawn 9.4%, room temp.: U. T. S. = 66,300 psi - Y. S. = 38,300 psi (0.2% offset), bar supplied - 1/2 inch diam. Bar sample - 0.3 inch diam., R. R. Moore - 3500 r.p.m., R = -1, data spread = ±5%.	60.0	39.2	0.7				11
11b	Cold drawn 11.5%, room temp.: U. T. S. = 69,600 psi - Y. S. = 50,500 psi (0.2% offset). Other specifications same as 11a.	60.0	39.1	0.9				11
11c	Cold drawn 11.5%, room temp.: U. T. S. = 69,900 psi - Y. S. = 53,700 psi (0.2% offset). Other specifications same as 11a.	60.0	39.1	0.8				11
11d	Cold drawn 11.5%, room temp.: U. T. S. = 72,300 psi - Y. S. = 55,000 psi (0.2% offset). Other specifications same as 11a.	60.0	39.0	0.9				11
56a	Drawn 24% - "fine grain," room temp.: U. T. S. = 87,000 psi - Y. S. = 72,500 psi (0.2% offset), bar - 0.5 inch diam. Sample - 0.3 inch diam., rotating cantilever - 8000 r.p.m.	59.9	39.3	0.7			0.1Pb	56
56b	Drawn 24% - "course grain," room temp.: U. T. S. = 87,300 psi - Y. S. = 68,800 psi (0.2% offset). Other specifications same as 56a.	59.7	39.4	0.7			0.1Pb	56
56c	Drawn 27% - "fine grain," room temp.: U. T. S. = 87,200 psi - Y. S. = 76,500 psi (0.2% offset), bar - 0.53 inch diam. Sample - 0.5 inch diam., rotating cantilever - 8000 r.p.m.	60.5	38.6	0.7			0.1Pb	56
56d	Drawn 27% - "fine grain." Notched sample: 0.30 inch diam. at notch - 0.0006 inch notch radius (K_T = 15.8) - 60°. Other specifications same as 56c.	60.5	38.6	0.7			0.1Pb	56
56e	Drawn 27% - "course grain," room temp.: U. T. S. = 91,400 psi - Y. S. = 79,000 psi (0.2% offset). Other specifications same as 56c.	60.4	38.7	0.8			0.1Pb	56
56f	Drawn 27% - "course grain." Other same as 56d.	60.4	38.7	0.8			0.1Pb	56
211	Hot rolled, room temp.: U. T. S. = 59,300 psi. Rotating cantilever - 2140 r.p.m., R = -1, data spread = ± 5%.	60.7	38.3	0.9				211
232a	Rolled, R_B = 73, room temp.: U. T. S. = 68,200 psi - R_B = 73, bar supplied - 3/4 inch diam. Bar sample - reduced - 1-15/16 inches long × 0.27 inch diam., rotating beam - 1750 r.p.m., R = -1.	61.2	38.3	0.4			0.1Pb	232
232b	Rolled - R_B = 73, bar - 3/4 inch diam. Sample - 0.404 inch diam. at notch - 60° - 0.010 inch notch radius (K_T = 4.5) - 0.480 inch diam. away from notch, rotating beam - 1750 r.p.m., R = -1.	61.2	38.3	0.4			0.1Pb	232
233	Room temp.: U. T. S. = 68,200 psi. R. R. Moore 1500 r.p.m., R = -1, data spread = ± 5%.	60.8	38.3	0.8				233
357	Annealed, bar - 3/4 inch diam. Notched sample: U-notch - 0.050 inch radius - 0.188 inch diam. at notch bottom (K_T = 1.37), 0.375 inch diam. away from notch, sample attached one end - vibrated longitudinally at approx. 14.2Kc.p.s., R = -1, tested in distilled water.							357

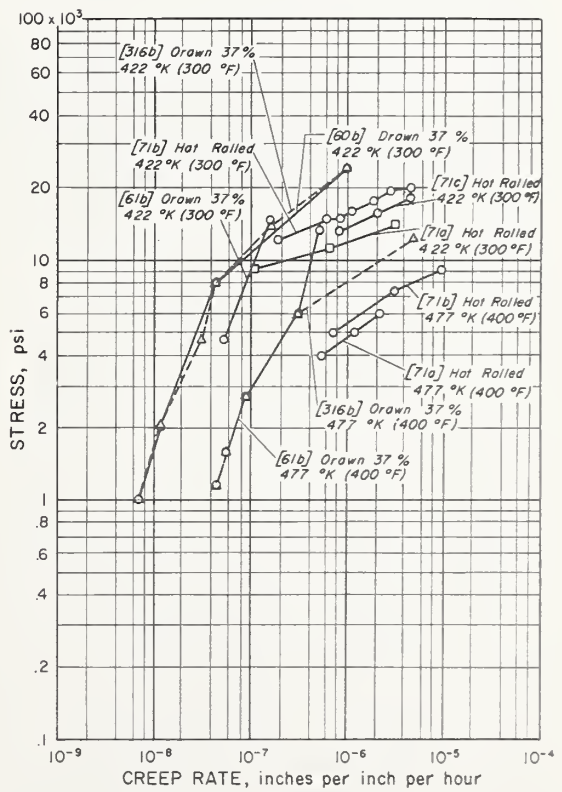


Creep Behavior of 60Cu-39Zn-1Sn (Naval Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
9a	Annealed 1500°F - Brinell hardness = 96, bar supplied - 3/4 inch diam., total test time = 250 hrs.	59.9	39.2	0.8				9
60a	Annealed 1000°F, room temp.: U.T.S. = 64,500 psi - Y.S. = 31,500 (0.5% strain). Bar sample - 1/8 inch diam., 10 inch G.L.	59.9	39.4	0.7				60
61a	Annealed 1000°F, room temp.: U.T.S. = 66,000 psi - Y.S. = 30,500 psi (0.5% strain). Bar sample - 1/8 inch diam., 10 inch G.L.	59.9	39.4	0.7				61
316a	Annealed 1000°F. Bar sample - 0.125 inch diam., 300°F: second stage creep except for 20,000 psi: third stage; 400°F: second stage; 500°F: second stage except for 1,300 psi; third stage.	60.0	39.4	0.6				316
420a	Annealed - 0.025mm. G.S., bar supplied - 0.75 inch diam.	58.8	40.4	0.8				420
420b	Annealed - 0.045mm. G.S., bar supplied - 0.75 inch diam.	60.1	38.7	0.8				420

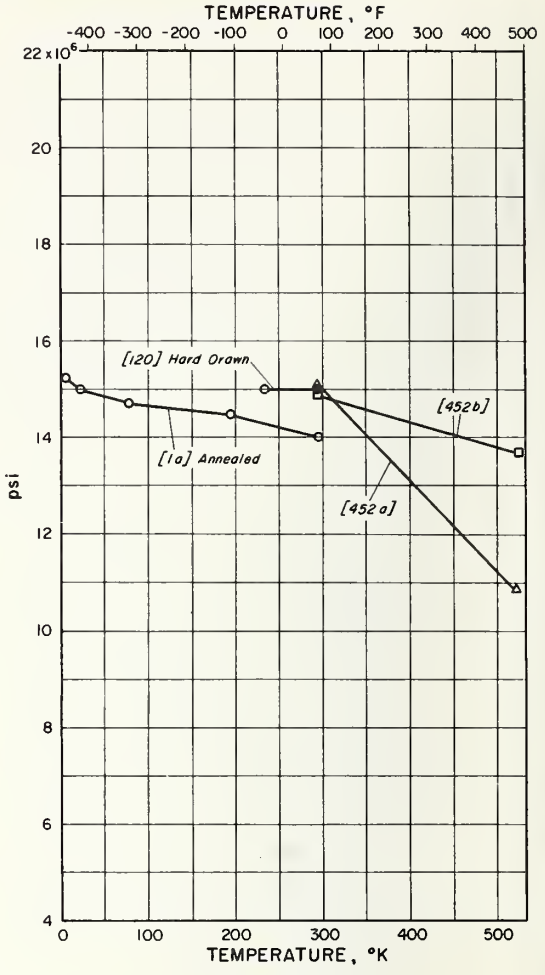


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
60b	Drawn 37%, room temp.: U.T.S. = 95,000 psi - Y.S. = 66,000 psi (0.5% strain). Bar sample - 1/8 inch diam., 10 inch G.L.	59.9	39.4	0.7				60
61b	Drawn 37%, room temp.: U.T.S. = 95,000 psi - Y.S. = 66,000 psi (0.5% strain). Bar sample - 1/8 inch diam., 10 inch G.L.	59.9	39.4	0.7				61
71a	Hot rolled - 0.020mm. G.S., bar supplied - 3/4 inch diam.	60.2	39.7	0.2				71
71b	Hot rolled - 0.025mm. G.S., bar supplied - 3/4 inch diam.	58.8	40.3	0.9				71
71c	Hot rolled - 0.045mm. G.S., bar supplied - 3/4 inch diam.	60.1	38.7	0.8				71
316b	Drawn 37%. Bar sample - 0.125 inch diam. Second stage creep.	60.0	39.4	0.6				316



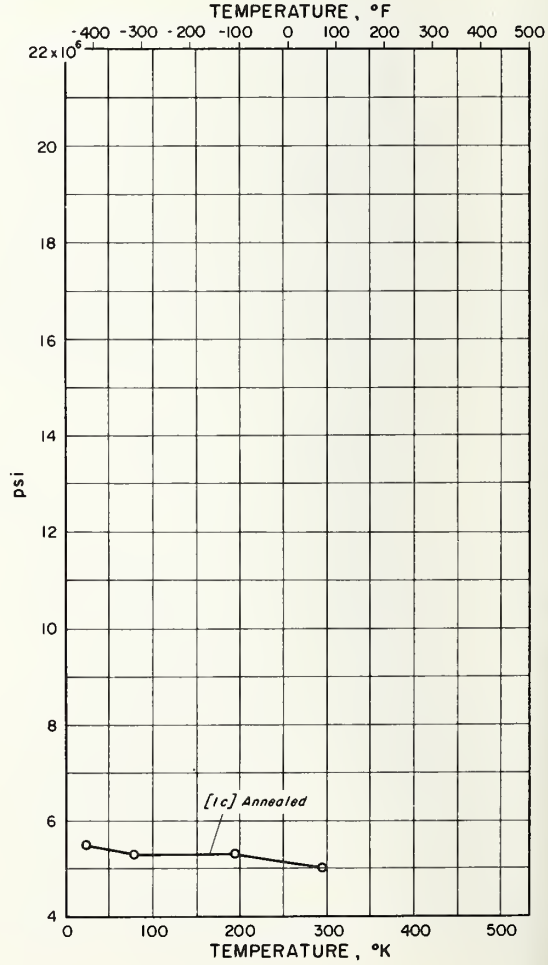
Modulus of Elasticity of 60Cu-39Zn-1Sn (Naval Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 1100°F - 1 hr. - 0.036mm. G.S. - R_B = 57, bar supplied - 3/4 inch diam. Bar sample - reduced section: 0.25 inch diam. X 1-1/2 inch long, clamp-on, strain gage extensometer - 1 inch G.L.	59.6	39.7	0.6			0.1Pb	1
120	Hard drawn. Bar sample - 0.375 inch diam.	62.6	37.0	0.3			0.1Pb	120
452a		59.0	39.8	0.6			0.6Pb	452
452b		56.9	40.3	0.8	0.2	0.2	0.7Fe, 0.7Pb, 0.2Mn	452



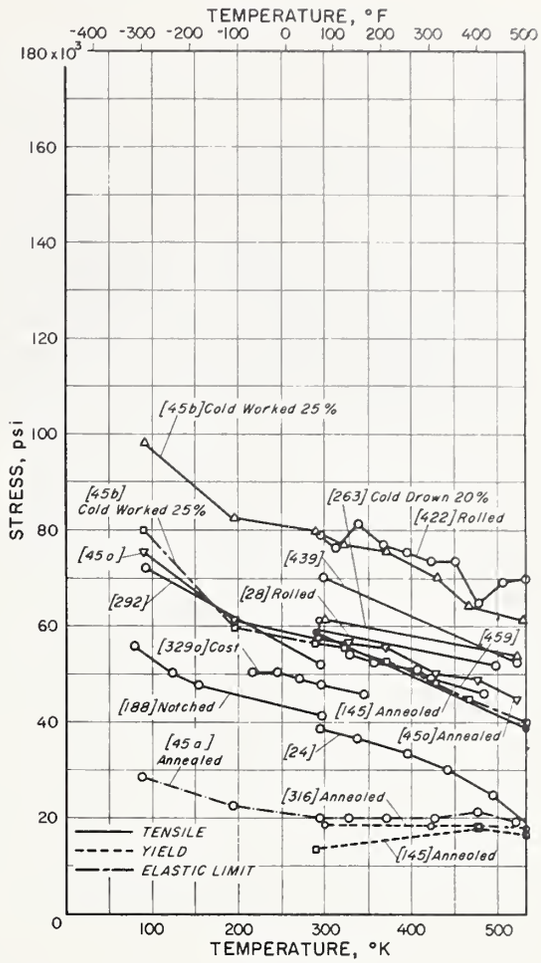
Modulus of Rigidity of 60Cu-39Zn-1Sn (Naval Brass)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1c	Annealed 1000°F - 1/2 hr., bar supplied - 3/4 inch diam. Bar sample - reduced section: 2.5 inches long X 0.125 inch diam., shear modulus determined isothermally by applying weights, maximum shear stress of 350 psi, data spread = ± 2%.	59.6	39.7	0.6			0.1Pb	1



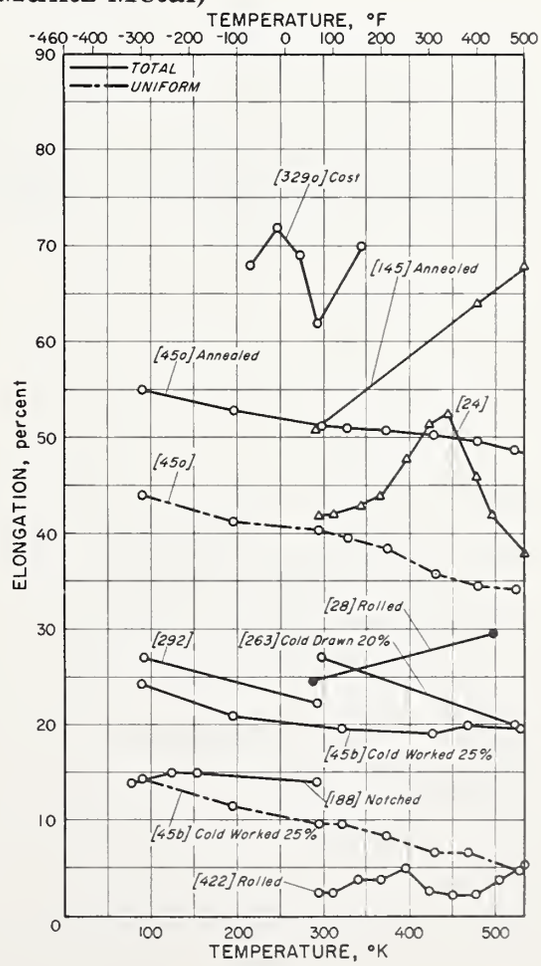
Tensile and Yield Strength of 60Cu-40Zn (Muntz Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
24	Wrought.	60.0	40.0					24
28	Rolled, bar supplied - 1/2 inch diam. Bar sample - 1/4 inch diam.	59.5	39.4			0.4	0.7Pb	28
45a	Annealed 1022°F - 2 hrs. - CO_2 atmos. Bar sample - 0.197 inch diam.	60.0	40.0					45
45b	Cold worked 25%. Bar sample - 0.197 inch diam.	60.0	40.0					45
145	Annealed 1112°F - after extruding. Bar sample.	60	40					145
188	Notched plate sample: 0.61 inch thick - 0.75 inch between notches - approx. 0.01 inch notch radius ($K_T \approx 6.1$) - 45° included angle (Tipper notch).	61.1	38.7				0.2Pb	188
263	Cold drawn 20%. Bar sample - 0.505 inch diam., cross-head speed ≈0.25 inch/minute.	62.4	37.5					263
292		57.1	40.8				0.9Fe, 0.7Pb	292
316	Annealed 1050°F. Wire sample - 0.125 inch diam., Y.S. - 0.2% offset.	60.5	39.4					316
329a	Aged 6 months - after gravity die cast, chill cast bar supplied - 1 inch diam. Bar sample - 0.564 inch diam., at least 5 tests/temp.	60.9	39.0				0.1Fe	329
422	Rolled. Bar sample - 0.74 inch diam.	62	38					422
439								439
459	Wire sample, constant load applied while wire was heated at 36°F/minute until sample broke.	61.7	38.3					459



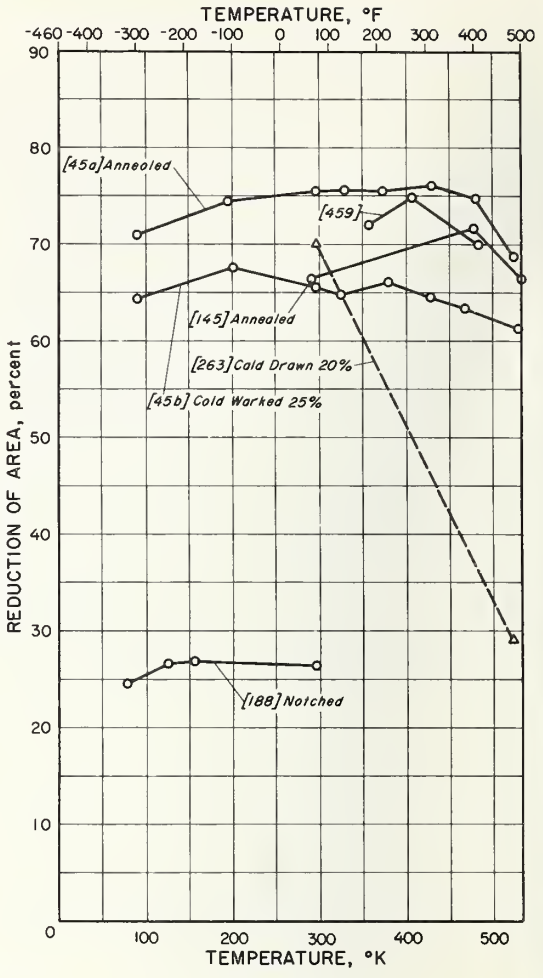
Tensile Elongation of 60Cu-40Zn (Muntz Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
24	Wrought. 2 inch G. L.	60.0	40.0					24
28	Rolled, bar supplied - 1/2 inch diam. Bar sample - 1/4 inch diam., 2 inch G. L.	59.5	39.4			0.4	0.7Pb	28
45a	Annealed 1022°F - 2 hrs. - CO_2 atmos. Bar sample - 0.197 inch diam., 1.97 inch G.L., lower curve denotes elongation prior to sample necking.	60.0	40.0					45
45b	Cold worked 25%. Bar sample 0.197 inch diam., 1.97 inch G.L., lower curve denotes elongation prior to sample necking.	60.0	40.0					45
145	Annealed 1112°F - after extruding. Bar sample, 2 inch G. L.	60	40					145
188	Notched plate sample: 0.61 inch thick - 0.75 inch between notches - approx. 0.01 inch notch radius ($K_T \approx 6.1$) - 45° included angle (Tipper notch).	61.1	38.7				0.2Pb	188
263	Cold drawn 20%. Bar sample - 0.505 inch diam., cross-head speed ≈0.25 inch/minute, 2 inch G. L.	62.4	37.5					263
292		57.1	40.8				0.9Fe, 0.7Pb	292
329a	Aged 6 months - after gravity die cast, chill cast bar supplied - 1 inch diam. Bar sample - 0.564 inch diam., at least 5 tests/temp., 2 inch G. L.	60.9	39.0				0.1Fe	329
422	Rolled. Bar sample - 0.74 inch diam.	62	38					422



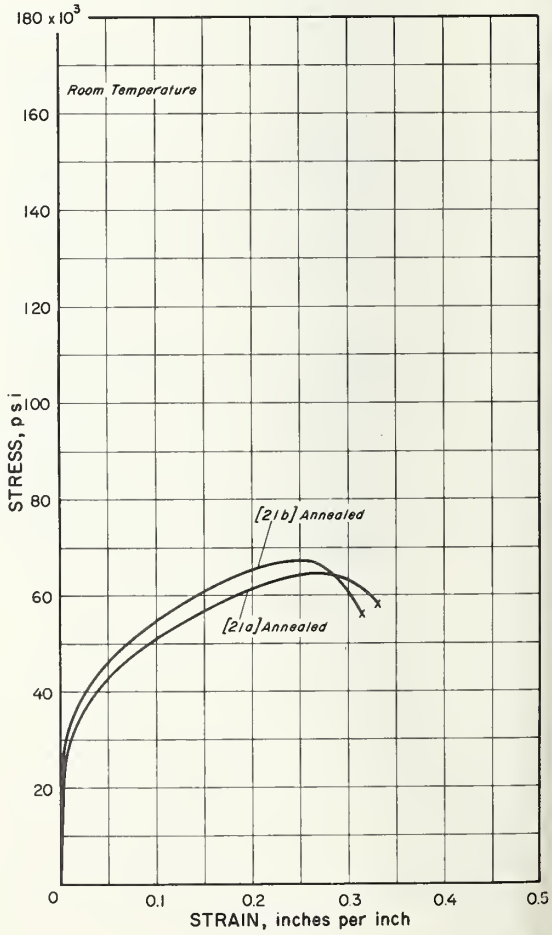
Tensile Reduction of Area of 60Cu-40Zn (Muntz Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
45a	Annealed 1022°F - 2 hrs. - CO_2 atmos. Bar sample - 0.197 inch diam., 1.97 inch G.L.	60.0	40.0					45
45b	Cold worked 25%. Bar sample - 0.197 inch diam., 1.97 inch G.L.	60.0	40.0					45
145	Annealed 1112°F - after extruding. Bar sample.	60	40					145
188	Notched plate sample: 0.61 inch thick - 0.75 inch between notches - approx. 0.01 inch notch radius ($K_T \approx 6.1$) - 45° included angle (Tipper notch).	61.1	38.7				0.2Pb	188
263	Cold drawn 20%. Bar sample - 0.505 inch diam., cross-head speed = 0.25 inch/minute.	62.4	37.5					263
459	Wire sample, constant load applied while wire was heated at 36°F/minute until sample broke.	61.7	38.3					459



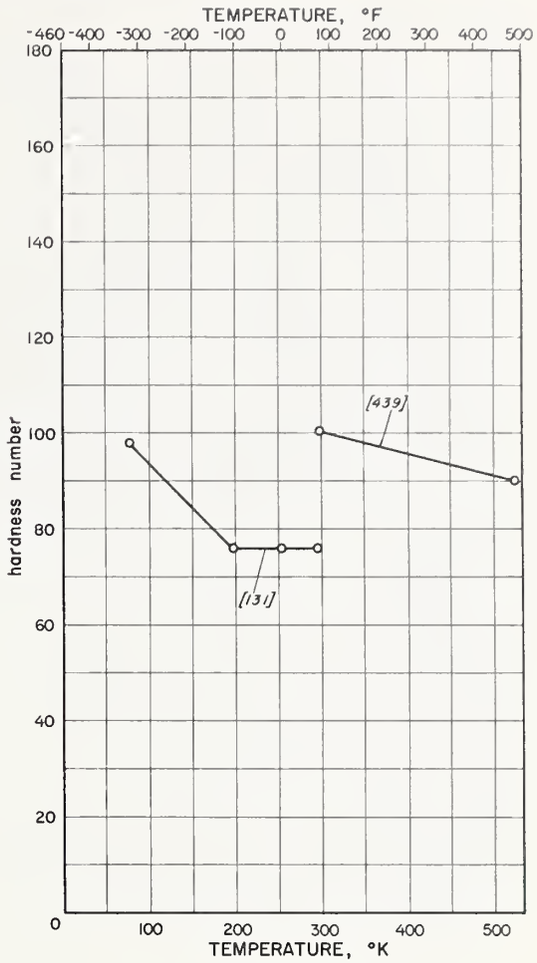
Tensile Stress-Strain Curves of 60Cu-40Zn (Muntz Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
21a	Annealed. Strain rate ≈ 0.001 inch/inch/sec.	61.4	38.6					21
21b	Annealed. Strain rate ≈ 100 inches/inch/sec.	61.4	38.6					21



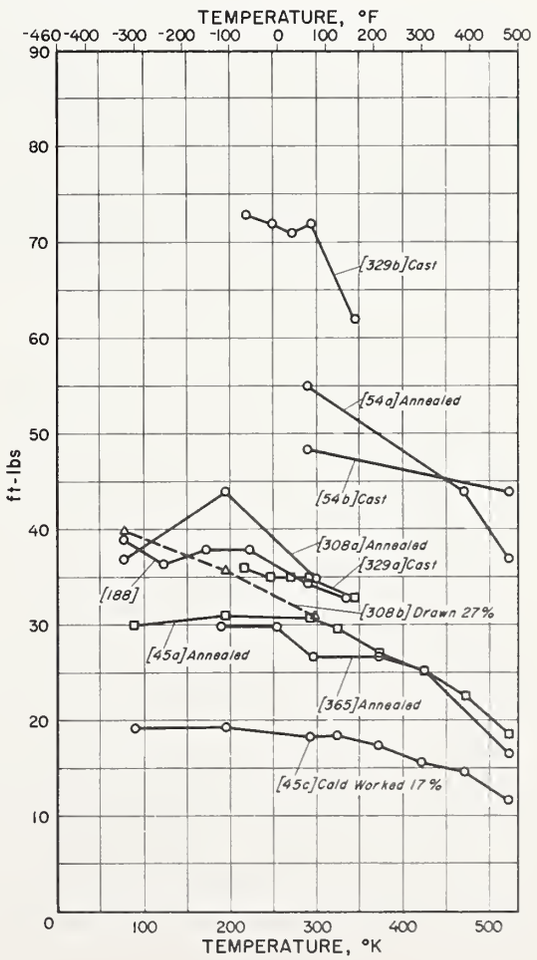
Hardness of 60Cu-40Zn (Muntz Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
131	Brinell - 3000 kgm. load.	60.4	39.3				0.2Pb	131
439	Brinell.							439



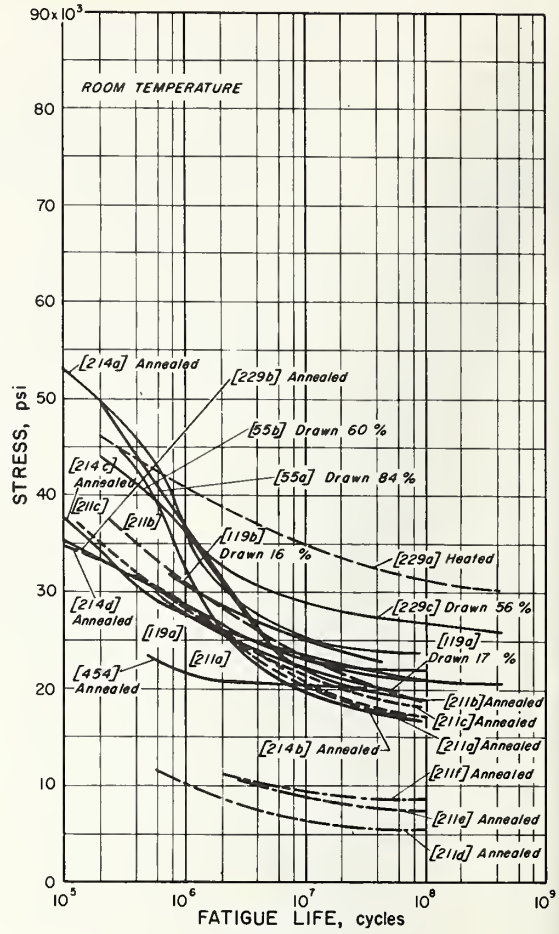
Impact Energy of 60Cu-40Zn (Muntz Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
45a	Annealed 1022°F - 2 hrs. - CO_2 atmos. Sample (Allemande type): V-notch - 45° - 3mm. deep - 8 X 10 X 100mm. cross-section.	60.0	40.0					45
45c	Cold worked 17%. Sample (Allemande type): V-notch - 45° - 3mm. deep - 8 X 10 X 100mm. cross-section.	60.0	40.0					45
54a	Annealed 1292°F - 4 hrs. - bar supplied - 1/2 inch square. Izod, samples did not fracture completely: bent 65° at 59°F and bent 60° at 392°F, temp. accuracy = ± 2°F.	61	39					54
54b	Chill - cast, bar supplied - 1/2 inch square. Izod, samples did not fracture completely: bent 65°, temp. accuracy = ± 2°F.	61	39					54
188	Plate supplied. Charpy V-notch.	61.1	38.7				0.2Pb	188
308a	Annealed. Charpy keyhole	61	39					308
308b	Drawn 27%. Charpy keyhole.	61	39					308
329a	Aged 6 months - after gravity die cast. Square sample - unnotched; 2.36 inch X 0.25 inch X 0.25 inch, tested in Charpy machine, temperature accurate to within ± 1°F. 10 to 15 tests/temp.	60.9	39.0				0.1Fe	329
329b	Standard Charpy V-notch except for length: 2.36 inches. Other specifications same as 329a.	60.9	39.0				0.1Fe	329
365	Annealed - Brinell hardness = 93. Sample ASTM standard Charpy V except for length: 2.36 inches. 75 to 212°F - tested in water; 212 to 482°F - tested in oil bath, tested longitudinally.	59.9	40.0					365

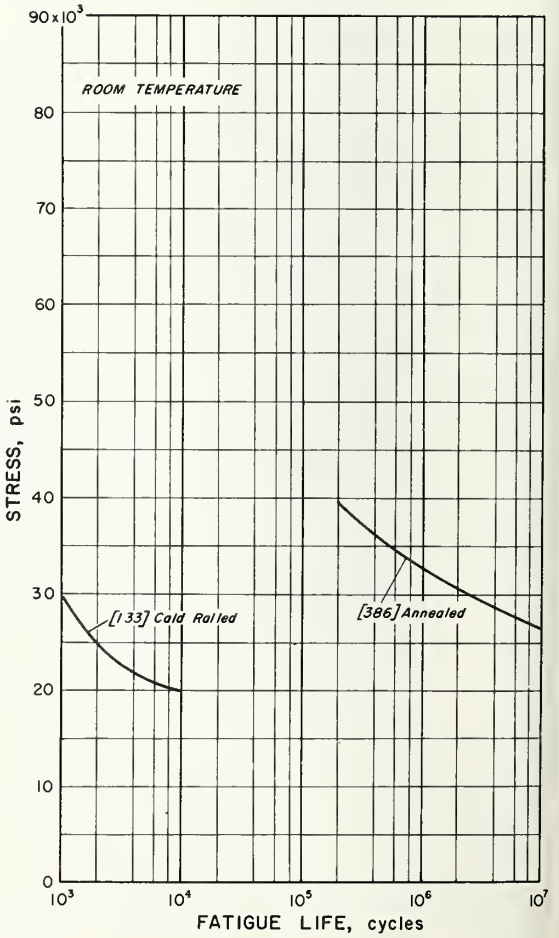


Fatigue Behavior of 60Cu-40Zn (Muntz Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
55a	Drawn 84%, room temp.: U. T. S. = 118,000 psi - Y. S. = 82,000 psi (0.2% offset). Wire sample - 0.072 inch diam., rotating arc - 3450 r.p.m., R = -1.	62.6	37.4					55
55b	Drawn 60%, room temp.: U. T. S. = 93,000 psi - Y. S. = 66,000 psi (0.2% offset). Other specifications same as 55a.	62.6	37.4					55
119a	Drawn 17%, room temp.: U. T. S. = 60,400 psi. Rotating beam - 2400 r.p.m.	61.6	38.3				0.1Pb	119
119b	Drawn 16.3%, room temp.: U. T. S. = 59,400 psi. Rotating beam - 1760 r.p.m.	61.5	37.9				0.5Pb	119
211a	Annealed 480°F - after hot rolling and quenching in ice brine, room temp.: U. T. S. = 76,600 psi. Rotating cantilever - 1800 r.p.m., R = -1, data spread = ± 7%.	59.5	40.1	0.1			0.1Fe, 0.2Pb	211
211b	Annealed 650°F, room temp.: U. T. S. = 79,200 psi. Other specifications same as 211a.	59.5	40.1	0.1			0.1Fe, 0.2Pb	211
211c	Annealed 840°F, room temp.: U. T. S. = 65,600 psi. Other specifications same as 211a.	59.5	40.1	0.1			0.1Fe, 0.2Pb	211
211d	Annealed 480°F - after hot rolling and quenching in ice brine. Alternating torsion - 2140 c.p.m., R = -1, data spread = ± 14%.	59.5	40.1	0.1			0.1Fe, 0.2Pb	211
211e	Annealed 650°F. Data spread = ± 7%. Other specifications same as 211d.	59.5	40.1	0.1			0.1Fe, 0.2Pb	211
211f	Annealed 840°F. Data spread = ± 10%. Other specifications same as 211d.	59.5	40.1	0.1			0.1Fe, 0.2Pb	211
214a	Annealed (stress relief), room temp.: Y. S. = 58,000 psi. Rotating cantilever - 1450 r.p.m., tested in air.							214
214b	Tested in salt water. Other specifications same as 452a.							214
214c	Annealed (full), room temp.: U. T. S. = 53,500 psi - Y. S. = 22,000 psi. Rotating cantilever - 1450 r.p.m. Tested in air.							214
214d	Tested in salt water. Other specifications same as 214c.							214
229a	Heated - after extruding and drawing, room temp.: U. T. S. = 66,000 psi, bar - 3/4 inch diam. Rotating beam (Farmer) - 1500 r.p.m., R = -1, data spread = ± 7%.	60.3	39.6					229
229b	Annealed - after extruding and drawing, room temp.: U. T. S. = 54,200 psi. Other specifications same as 229a.	59.8	40.1					229
229c	Drawn 56%, room temp.: U. T. S. = 96,700 psi. Other specifications same as 229a.							229
454	Annealed 1000°F - 1/2 hr. - air cooled, room temp.: U.T.S. = 49,000 psi - Y. S. = 18,600 psi - Brinell hardness = 70. Bar sample - 13 inches long; 3 unreduced sections: 1/2 inch diam. 2 reduced sections: 1-1/2 inches long × 0.334 inch diam., rotating beam.	60.0	40.0					454

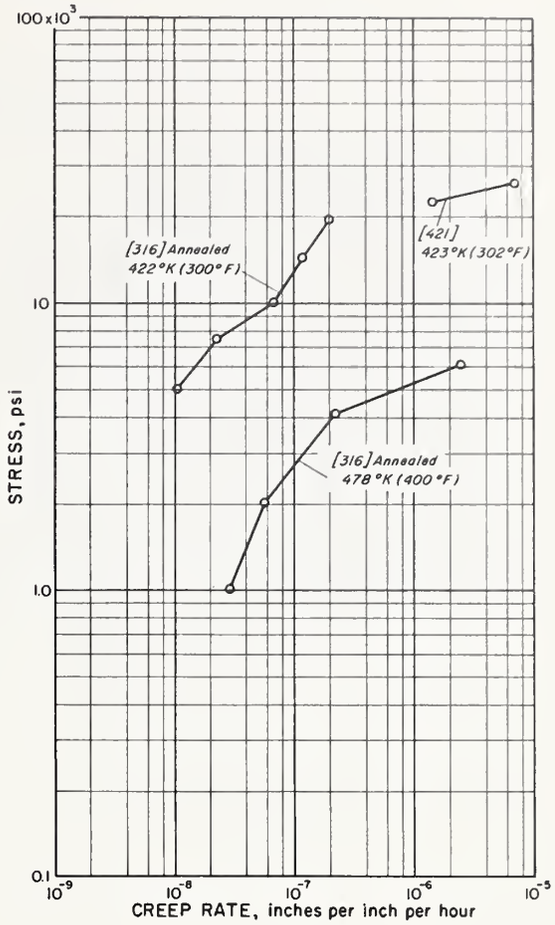


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
133	Cold rolled, room temp.: U. T. S. = 55,500 psi - Y. S. = 42,500 psi (0.2% offset) - R_B = 70, bar supplied - 3/4 inch diam. Tubular sample: 9/16 inch outer diam. - 7/16 inch inner diam., cyclic torsion apparatus, 5 to 10 c.p.m. R = -1.							133
386	Annealed 600°C - 2 hrs., room temp.: U. T. S. = 58,600 psi - Y. S. = 20,000 psi (0.2% offset) - R_F = 75.5. Bar sample - 0.658 inch diam., rotating beam.	60.1	39.9					386



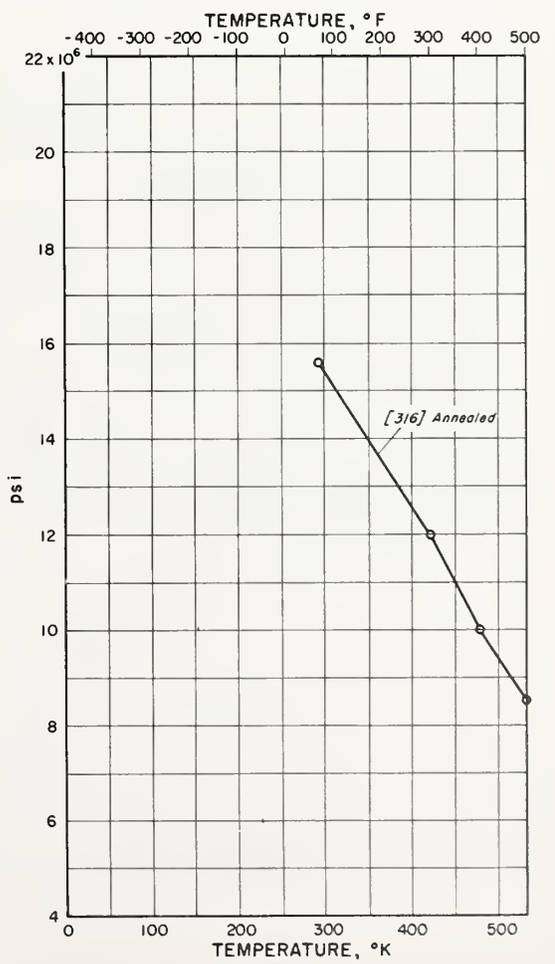
Creep Behavior of 60Cu-40Zn (Muntz Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
316	Annealed 1050°F. Bar sample - 0.125 inch diam. Second stage creep.	60.5	39.4					316
421	Room temp.; U.T.S. = 60,600 psi. Bar sample - approx. 0.25 inch diam., temp. accuracy = ± 2°C, extension measured within 0.0001 inch, creep curves stepped; rate recorded is that which occurred between steps, 2 inch G.L.	59.8	38.7	0.3			1.0Pb, 0.2Fe	421



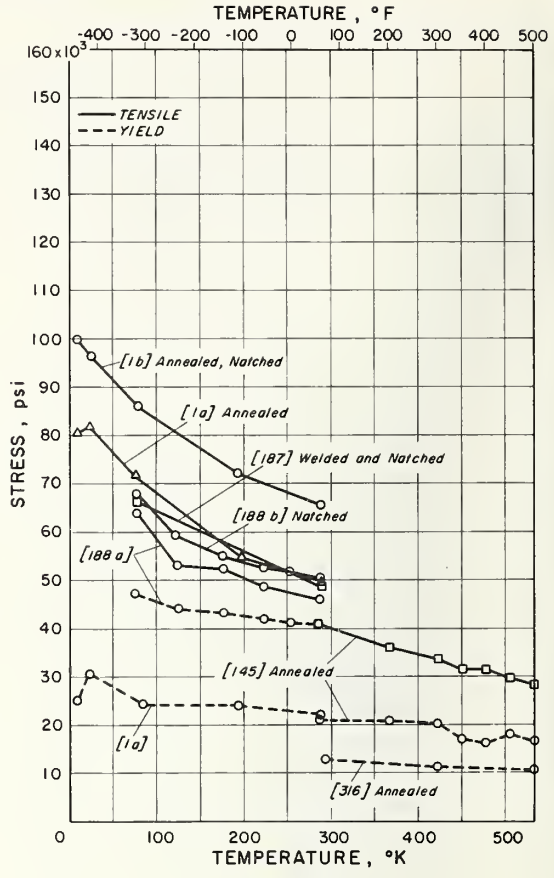
Modulus of Elasticity of 60Cu-40Zn (Muntz Metal)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
316	Annealed 1050°F. Wire sample - 0.125 inch diam.	60.5	39.4					316



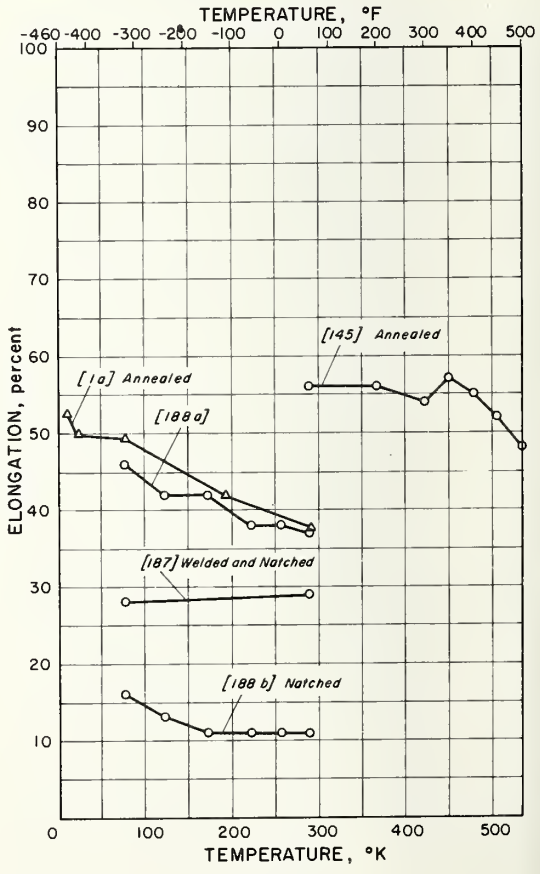
Tensile and Yield Strength of 90Cu-10Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 677°C - 40 minutes - 0.051mm. G.S. - R_B = 33, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch diam., crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer, Y.S. = 0.2% offset.	Bal	0.1			10.0	1.2Fe	1
1b	Material specifications same as 1a. Bar sample - notched - 0.25 inch diam. of roots of 0.005 ± 0.0005 inch notch radius (K_T = 5.0).	Bal	0.1			10.1	1.2Fe	1
145	Annealed 1202°F - 20 minutes. Bar sample - reduced section - 2 inches long X 0.8 inch diam., strength plotted is breaking strength, Y.S. - 0.3% strain.					~12		145
187	Welded plate supplied - parent: 92Cu-6Ni - 1Fe; filler composition given, edge preparation: single U-1/8 inch root face - 1/8 inch land - 1/8 inch root radius - 20° bevel - no root gap, plates butt welded - weld deposits prepared by argon-shielded arc - consumable electrode; D.C. welding current - 350 amps.; welding speed - 4 to 6 inches/minute, notched plate sample: 0.79 inch thick - assume 0.76 inch between notches - approx. 0.01 inch notch radius (K_T = 6.2) - 45° included angle (Tipper notch).	64.8				33.5	0.6Mn, 0.5Fe, 0.2Ti, 0.2Si, 0.1Mg	187
188a	Plate sample - 0.52 inch thick X 0.625 inch wide, Y.S. - 0.2% offset.	89.7	0.2			10.0	0.1Fe, 0.1Mn	188
188b	Notched plate sample: 0.52 inch thick - 0.79 inch between notches - approx. 0.01 inch notch radius (K_T = 6.3) - 45° included angle (Tipper notch).	89.7	0.2			10.0	0.1Fe, 0.1Mn	188
316	Annealed - 0.030mm. G.S., bar supplied - 0.125 inch diam.	89.1				10.1	0.7Fe, 0.2Mn	316



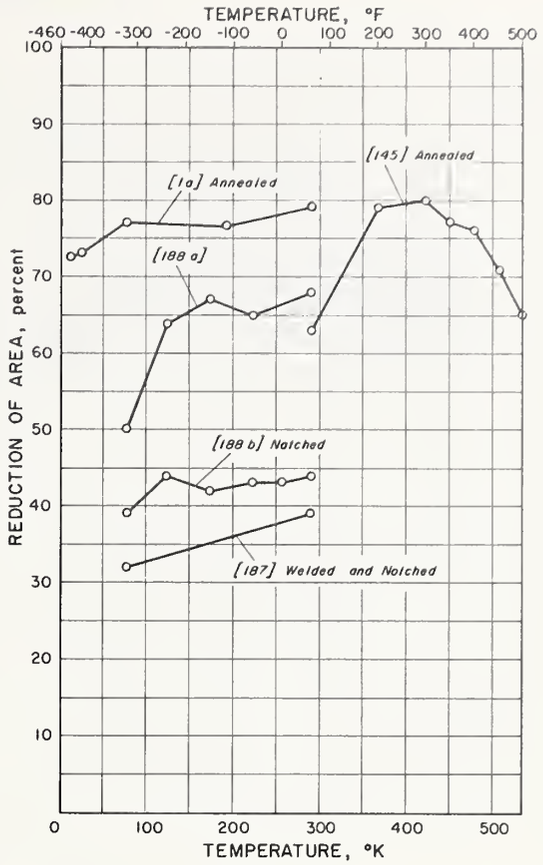
Tensile Elongation of 90Cu-10Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 677°C - 40 minutes - 0.051mm. G.S. - R_B = 33, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch diam., crosshead speed = 0.02 inches/minute, 1 inch G.L.	Bal	0.1			10.0	1.2Fe	1
145	Annealed 1202°F - 20 minutes. Bar sample - reduced section - 2 inches long X 0.8 inch diam.					≈12		145
187	Welded plate supplied - parent: 92Cu-6Ni-1Fe; filler composition given, edge preparation: single U-1/8 inch root face - 1/8 inch land - 1/8 inch root radius - 20° bevel - no root gap, plates butt welded - weld deposits prepared by argon shielded arc - consumable electrode - D.C. welding current - 350 amps.; welding speed - 4 to 6 inches/minute, notched plate sample: 0.79 inch thick - assume 0.76 inch between notches - approx. 0.01 inch notch radius (K_T = 6.2) - 45° included angle (Tipper notch), 2 inch G.L.	64.8				33.5	0.6Mn, 0.5Fe, 0.2Ti, 0.2Si, 0.1Mg	187
188a	Plate sample - 0.52 inch thick X 0.625 inch wide, 1.5 inch G.L.	89.7	0.2			10.0	0.1Fe, 0.1Mn	188
188b	Notched plate sample: 0.52 inch thick - 0.79 inch between notches - approx. 0.01 inch notch radius (K_T = 6.3) - 45° included angle (Tipper notch), 2 inch G.L.	89.7	0.2			10.0	0.1Fe, 0.1Mn	188



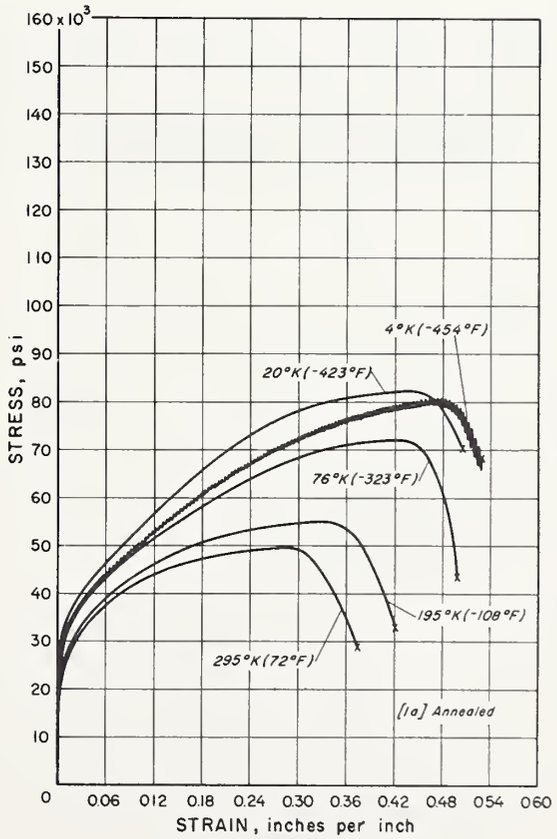
Tensile Reduction of Area of 90Cu-10Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 677°C - 40 minutes - 0.051mm. G.S. - R_B = 33, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch diam., crosshead speed = 0.02 inch/minute.	Bal	0.1			10.0	1.2Fe	1
145	Annealed 1202°F - 20 minutes. Bar sample - reduced section - 2 inches long X 0.8 inch diam.					≈12		145
187	Welded plate supplied - parent: 92Cu-6Ni-1Fe; filler composition given, edge preparation: single U - 1/8 inch root face - 1/8 inch land - 1/8 inch root radius - 20° bevel - no root gap, plate butt welded - weld deposits prepared by argon shielded arc - consumable electrode; D.C. welding current - 350 amps,; welding speed - 4 to 6 inches/minute, notched plate sample: 0.79 inch thick - assume 0.76 inch between notches - approx. 0.01 inch notch radius (K_T = 6.2) - 45° included angle (Tipper notch).	64.8				33.5	0.6Mn, 0.5Fe, 0.2Ti, 0.2Si, 0.1Mg	187
188a	Plate sample - 0.52 inch thick X 0.625 inch wide.	89.7	0.2			10.0	0.1Fe, 0.1Mn	188
188b	Notched plate sample: 0.52 inch thick - 0.79 inch between notches - approx. 0.01 inch notch radius (K_T = 6.3) - 45° included angle (Tipper notch).	89.7	0.2			10.0	0.1Fe, 0.1Mn	188



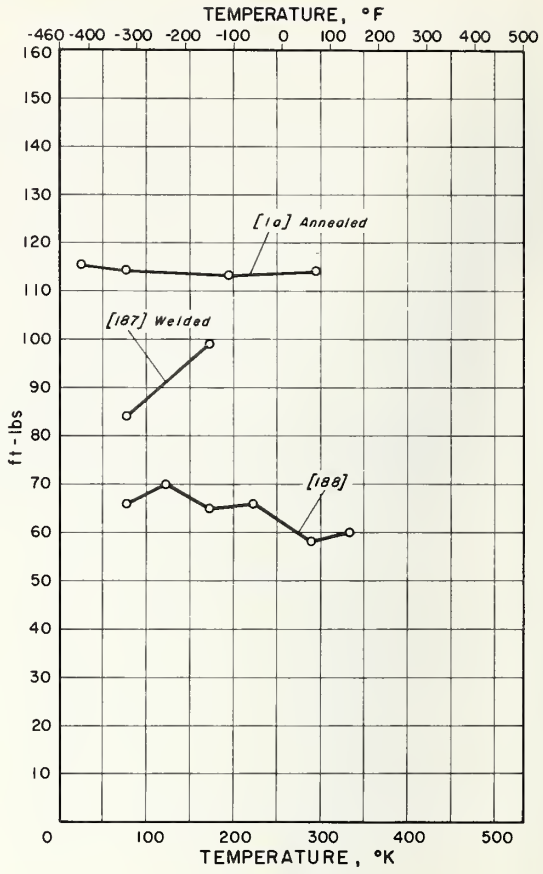
Tensile Stress-Strain Curves of 90Cu-10Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 677°C - 40 minutes - 0.051mm. G.S. - R_B = 33, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer - 1 inch G.L., data spread = ± 5%.	Bal	0.1			10.0	1.2Fe,	1



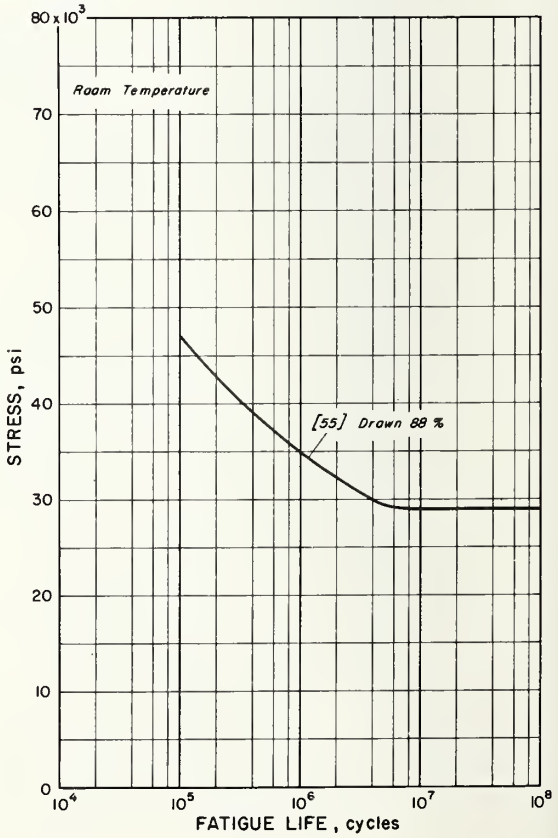
Impact Energy of 90Cu-10Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed 677°C - 40 minutes - 0.051mm. G.S. - R_B = 33, bar supplied - 3/4 inch diam. Charpy V, hammer velocity = 16 ft./sec., paper container glued to sample used for -423°F tests, 10% fracture at all temps.	Bal	0.1			10.0	1.2Fe	1
187	Welded plate supplied - parent: 92Cu-6Ni-1Fe; filler composition given, edge preparation: single U- 1/8 inch root face - 1/8 inch land - 1/8 inch root radius - 20° bevel - no root gap, plates butt welded - weld deposits prepared by argon shielded arc - consumable electrode; D.C. welding current - 350 amps.; welding speed - 4 to 6 inches/minute. Charpy V-notch.	64.8				33.5	0.6Mn, 0.5Fe, 0.2Ti, 0.2Si, 0.1Mg	187
188	Charpy V-notch.	89.6	0.2			10.0	0.1Fe, 0.1Mn	188



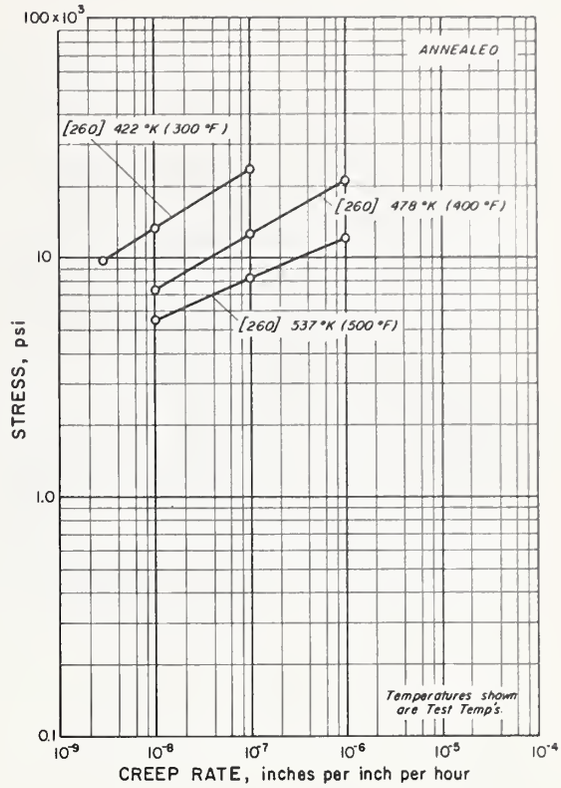
Fatigue Behavior of 90Cu-10Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
55	Drawn 88%, room temp.: U.T.S. = 69,500 psi - Y.S. = 67,000 psi (0.2% offset). Wire sample - 0.072 inch diam., rotating arc - 3450 r.p.m., R = -1, sample at 29,000 psi - 5 X 10^7 cycles did not break.	89.5				10.1	0.5Mn	55



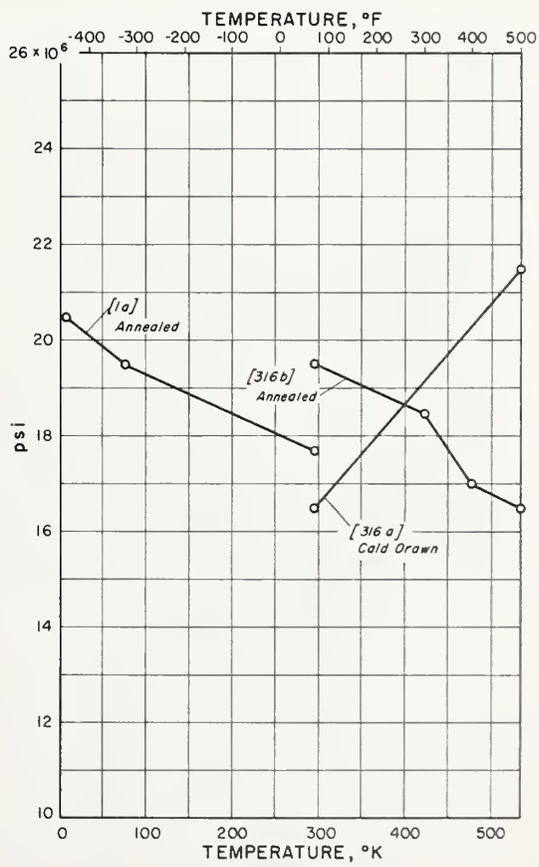
Creep Behavior of 90Cu-10Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
260	Annealed - 0.030mm. G.S., room temp.: Y.S. = 13,900 psi (0.5% strain). Bar sample - 0.125 inch diam., 10 inch G.L.	89.1				10.1	0.7Fe, 0.2Mn	260



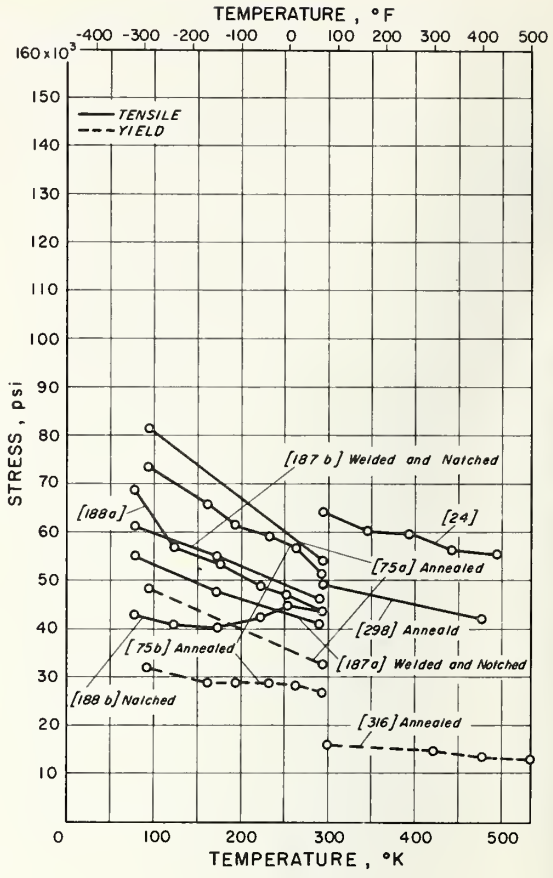
Modulus of Elasticity of 90Cu-10Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
1a	Annealed 677°C - 40 minutes - 0.051mm. G.S. - R_B = 33, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.250 inch diam., crosshead speed = 0.02 inch/minute, modulus derived from stress vs. strain curves, clamp-on strain gage extensometer, 1 inch G.L., data spread = ± 5%.	Bal				10.0	1.2Fe, 0.1Zn	1
316a	Cold drawn, bar supplied - 13/16 inch diam.	90.9				7.8	0.9Aℓ, 0.5Cd	316
316b	Annealed - 0.030mm. G.S. Bar sample - 0.125 inch diam.	89.1				10.1	0.7Fe, 0.2Mn	316



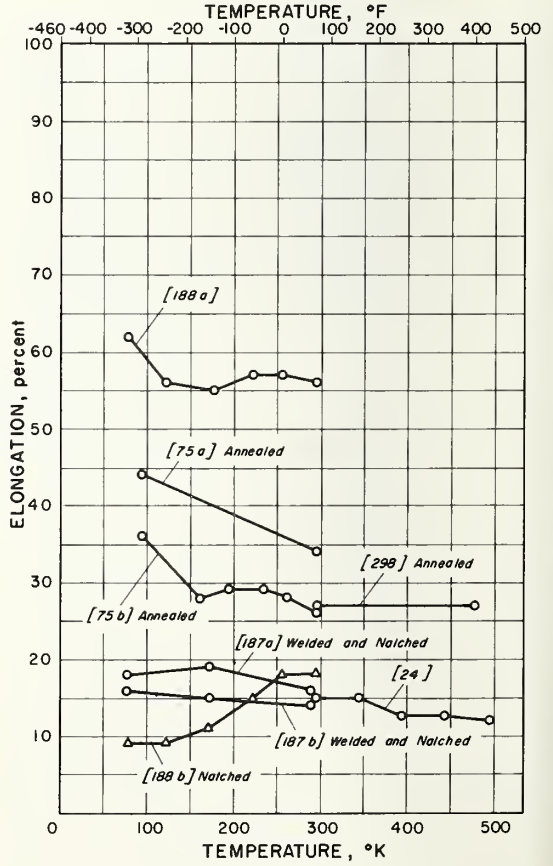
Tensile and Yield Strength of 80Cu-20Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
24		80.0				20.0		24
75a	Annealed - after rolling. Bar sample - 0.504 inch diam., Y.S. at 70°F - 0.1% offset; Y.S. at -292°F measured by drop of beam.	79.7				20.6	0.1Mn	75
75b	Annealed - after rolling. Bar sample - 0.25 inch diam., Y.S. - 0.1% offset.	79.7				20.6	0.1Mn	75
187a	Welded plate supplied - parent: 80Cu-20Ni; filler composition given, edge preparation: single - U - 1/8 inch root face - 1/8 inch land - 1/8 inch root radius - 20° bevel - no root gap, plates butt welded - weld deposits prepared by argon shielded arc - consumable electrode; D.C. welding current - 320 amps.; welding speed - 4 to 6 inches/minute. Notched sample: assumed 0.76 inch between notches - approx. 0.01 inch notch radius ($K_T \approx 6.2$) - 45° included angle (Tipper notch).	78.7				20.6	0.2Ti, 0.2Fe, 0.2Mn, 0.1Si	187
187b	Welded plate supplied - parent: 77Cu-22Ni-1Fe; filler composition given. Other specifications same as 187a.	78.7				20.6	0.2Ti, 0.2Fe, 0.2Mn, 0.1Si	187
188a	Plate sample - 0.625 inch thick X approx. 0.58 inch wide.	80.1	0.1			19.5	0.2Fe	188
188b	Notched plate sample: 0.79 inch thick - 0.595 inch between notches - approx. 0.01 inch notch radius ($K_T \approx 5.4$) - 45° included angle (Tipper notch).	80.1	0.1			19.5	0.2Fe	188
298	Annealed. Sheet sample.	79.6				20.0	0.4Mn	298
316	Annealed - 0.025mm. G.S. Bar sample - 0.125 inch diam., Y.S. - 0.2% offset.	78.5	0.8			20.0	0.6Mn, 0.1Fe	316



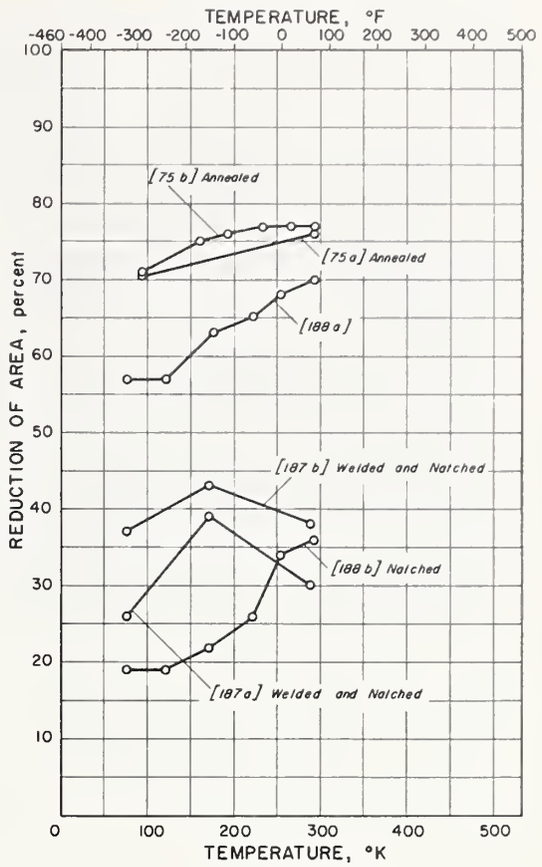
Tensile Elongation of 80Cu-20Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
24	2 inch G.L.	80.0				20.0		24
75a	Annealed - after rolling. Bar sample - 0.504 inch diam., 2 inch G.L.	79.7				20.6	0.1Mn	75
75b	Annealed - after rolling. Bar sample - 0.25 inch diam., 2 inch G.L.	79.7				20.6	0.1Mn	75
187a	Welded plate supplied - parent: 80Cu-20Ni; filler composition given, edge preparation: single U- 1/8 inch root face - 1/8 inch land - 1/8 inch root radius - 20° bevel - no root gap, plates butt welded - weld deposits prepared by argon shielded arc - consumable electrode; D.C. welding current = 320 amps.; welding speed = 4 to 6 inches/minute. Notched sample: assumed 0.76 inch between notches - approx. 0.01 inch notch radius ($K_T = 6.2$) - 45° including angle (Tipper notch), 2 inch G.L.	78.7				20.6	0.2Ti, 0.2Fe, 0.2Mn, 0.1Si	187
187b	Welded plate supplied - parent: 77Cu-22Ni-1Fe; filler composition given. Other specifications same as 187a.	78.7				20.6	0.2Ti, 0.2Fe, 0.2Mn, 0.1Si	187
188a	Plate sample - 0.625 inch thick X approx. 0.58 inch wide, 1.5 inch G.L.	80.1	0.1			19.5	0.2Fe	188
188b	Notched plate sample: 0.79 inch thick - 0.595 inch between notches - approx. 0.01 inch notch radius ($K_T = 5.4$) - 45° included angle (Tipper notch), 2 inch G.L.	80.1	0.1			19.5	0.2Fe	188
298	Annealed. Sheet sample, 2 inch G.L.	79.6				20.0	0.4Mn	298



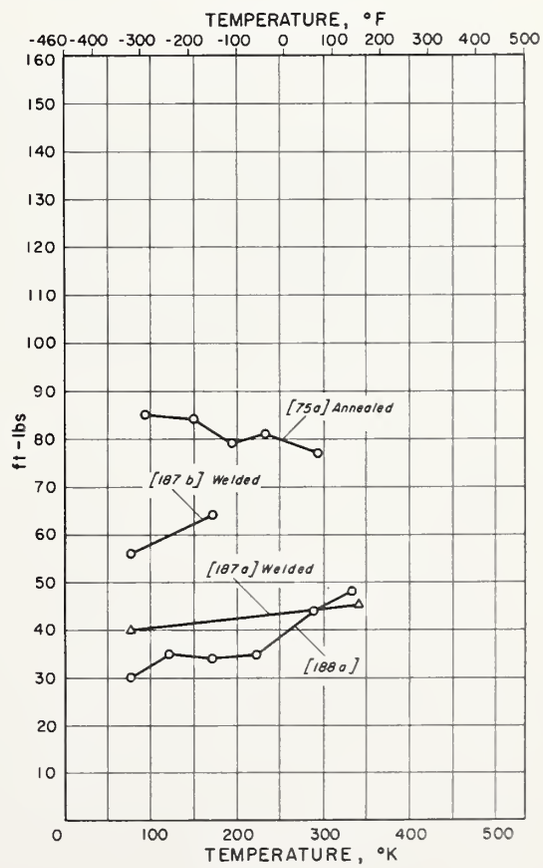
Tensile Reduction of Area of 80Cu-20Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
75a	Annealed - after rolling. Bar sample - 0.504 inch diam.	79.7				20.6	0.1Mn	75
75b	Annealed - after rolling. Bar sample - 0.25 inch diam.	79.7				20.6	0.1Mn	75
187a	Welded plate supplied - parent: 80Cu-20Ni; filler composition given, edge preparation: single U - 1/8 inch root face - 1/8 inch land - 1/8 inch root radius - 20° bevel - no root gap, plates butt welded - weld deposits prepared by argon shielded arc - consumable electrode - D.C. welding current = 320 amps.; welding speed = 4 to 6 inches/minute. Notched sample: assumed 0.76 inch between notches - approx. 0.01 inch notch radius ($K_T \approx 6.2$) - 45° included angle (Tipper notch).	78.7				20.6	0.2Ti, 0.2Fe, 0.2Mn, 0.1Si	187
187b	Welded plate supplied - parent: 77Cu-22Ni-1Fe; filler composition given. Other specifications same as 187a.	78.7				20.6	0.2Te, 0.2Fe, 0.2Mn, 0.1Si	187
188a	Plate sample - 0.625 inch thick X approx. 0.58 inch wide.	80.1	0.1			19.5	0.2Fe	188
188b	Notched plate sample: 0.79 inch thick - 0.595 inch between notches - approx. 0.01 inch notch radius ($K_T \approx 5.4$) - 45° included angle (Tipper notch).	80.1	0.1			19.5	0.2Fe	188



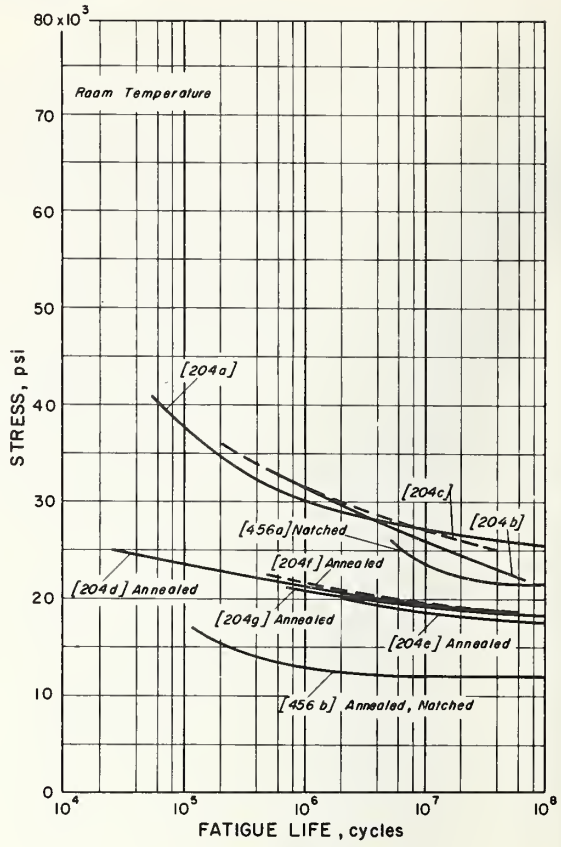
Impact Energy of 80Cu-20Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
75a	Annealed - after rolling. Izod.	79.7				20.6	0.1Mn	75
187a	Welded plate supplied - parent: 80Cu-20Ni; filler composition given, edge preparation: single U - 1/8 inch root face - 1/8 inch land - 1/8 inch root radius - 20° bevel - no root gap, plates butt welded - weld deposits prepared by argon shielded arc - consumable electrode; D.C. welding current = 320 amps.; welding speed = 4 to 6 inches/minute. Charpy V-notch.	78.7				20.6	0.2Ti, 0.2Fe, 0.2Mn, 0.1Si	187
187b	Welded plate supplied - parent: 77Cu-22Ni-1Fe; filler composition given. Charpy V-notch. Other specifications same as 187a.	78.7				20.6	0.2Ti, 0.2Fe, 0.2Mn, 0.1Si	187
188a	Charpy V-notch.	80.1	0.1			19.5	0.2Fe	188

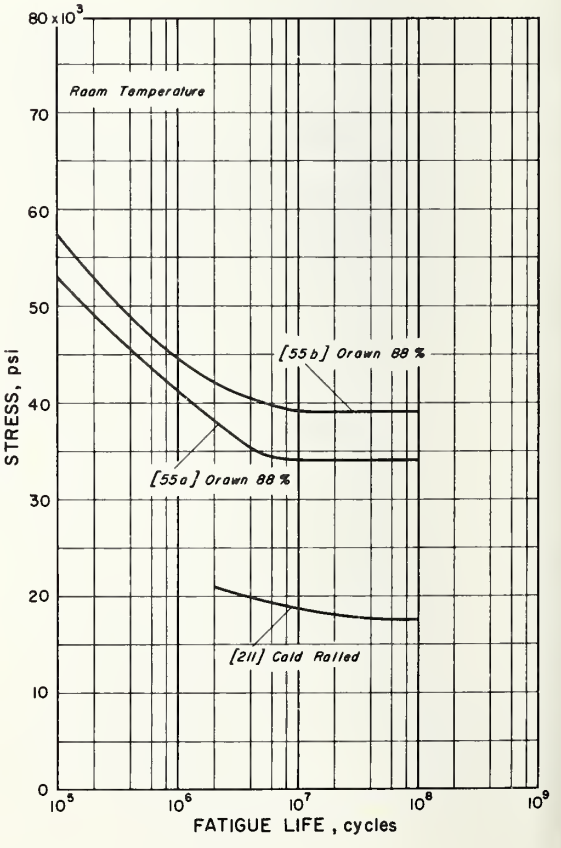


Fatigue Behavior of 80Cu-20Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
204a	Heated 400°F - 3 hrs. - furnace cooled. Sample conically tapered, rotating cantilever - 1450 r.p.m., tested in air.	77.9				21.2	0.5Fe, 0.3Mn	204
204b	Tested in fresh water containing carbon dioxide. Other specifications same as 204a.	77.9				21.2	0.5Fe, 0.3Mn	204
204c	Tested in salt water having approx. 1/3 salt of sea water. Other specifications same as 204a.	77.9				21.2	0.5Fe, 0.3Mn	204
204d	Annealed 1400°F - 1 hr. - furnace cooled. Other specifications same as 204a.	77.9				21.2	0.5Fe, 0.3Mn	204
204e	Annealed 1400°F - 1 hr. - furnace cooled. Sample conically tapered, rotating cantilever - 1200 r.p.m., tested in air.	77.9				21.2	0.5Fe, 0.3Mn	204
204f	Annealed 1400°F - 1 hr. - furnace cooled. Sample conically tapered, rotating cantilever - 1450 r.p.m., tested in salt water having approx. 1.3 salt of sea water.	77.9				21.2	0.5Fe, 0.3Mn	204
204g	Tested in fresh water containing carbon dioxide. Other specifications same as 204f.	77.9				21.2	0.5Fe, 0.3Mn	204
456a	Heated 400°F - 3 hrs. - furnace cooled, room temp.: U.T.S. = 61,000 psi - Y.S. = 47,000 psi. Notched sample - 0.5 inch diam. at circumferential notch - 0.0055 inch notch radius ($K_T \approx 6.72$), rotating cantilever - 1450 r.p.m. R = -1.	79.5				19.8	0.4Fe, 0.3Mn	456
456b	Annealed 1400°F - 1 hr. - furnace cooled, room temp.: U.T.S. = 47,500 psi - Y.S. = 12,000 psi. Other specifications same as 456a.	79.5				19.8	0.4Fe, 0.3Mn	456

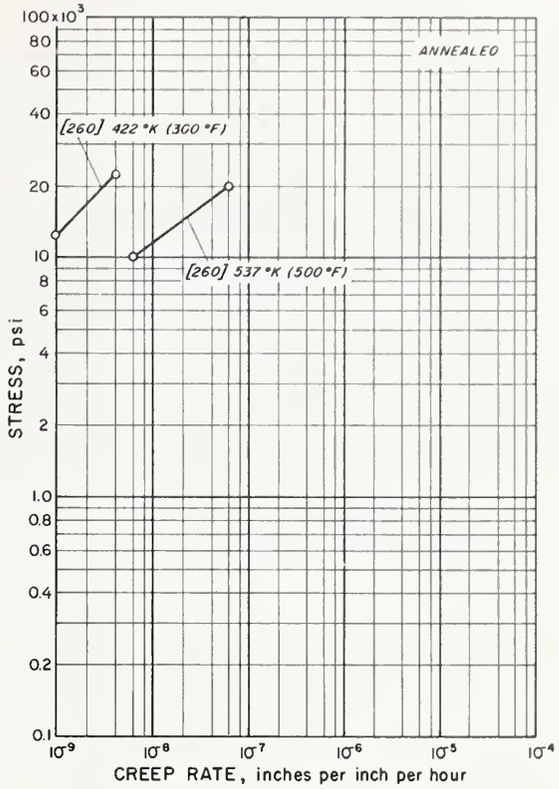


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
55a	Drawn 88%, room temp.: U.T.S. = 84,300 psi - Y.S. = 78,000 psi (0.2% offset). Wire sample - 0.072 inch diam., rotating arc - 3450 r.p.m., R = -1, samples at 33,500 and 34,000 psi - 10^8 cycles did not break.	79.5				20.0	0.5Mn	55
55b	Drawn 88%, room temp.: U.T.S. = 93,000 psi - Y.S. = 84,000 psi (0.2% offset). Wire sample - 0.072 inch diam., rotating arc - 3450 r.p.m., R = -1, sample at 38,500 psi - 4×10^7 cycles did not break.	75.8				23.4	0.5Mn	55
211	Cold rolled, room temp.: U.T.S. = 49,900 psi. Rotating cantilever - 1800 r.p.m., R = -1, data spread = ± 20%.	80.3				19.2	0.3Fe, 0.1Mn	211



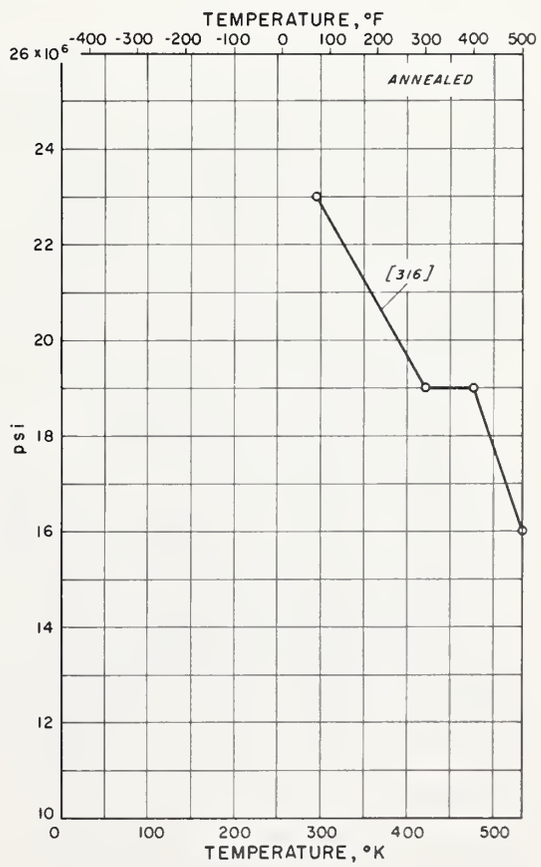
Creep Behavior of 80Cu-20Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
260	Annealed - 0.025mm. G.S., room temp.: U.T.S. = 52,500 psi - Y.S. = 16,400 psi (0.5% strain). Bar sample - 0.125 inch diam., 10 inch G.L.	78.5	0.8			20.0	0.6Mn, 0.2Fe	260



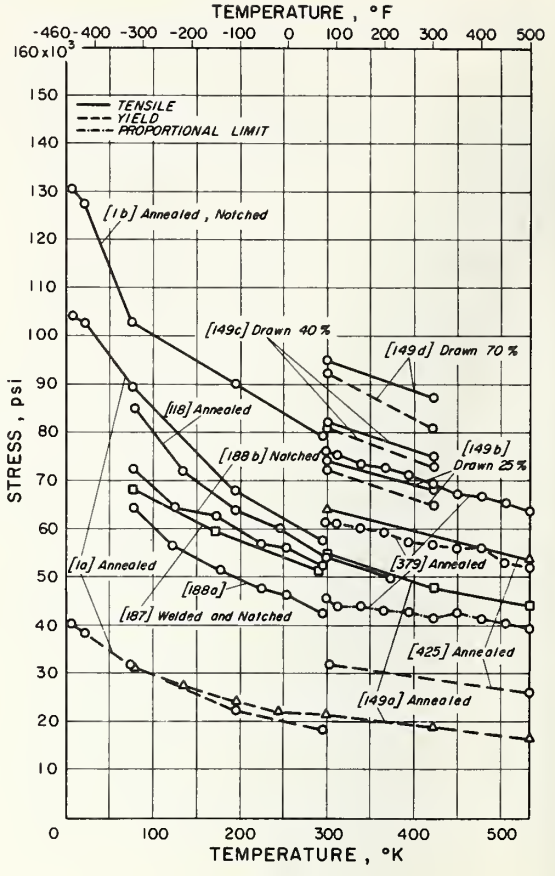
Modulus of Elasticity of 80Cu-20Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
316	Annealed - 0.025mm. G.S. Bar sample - 0.125 inch diam.	78.5	0.8			20.0	0.6Mn, 0.2Fe	316



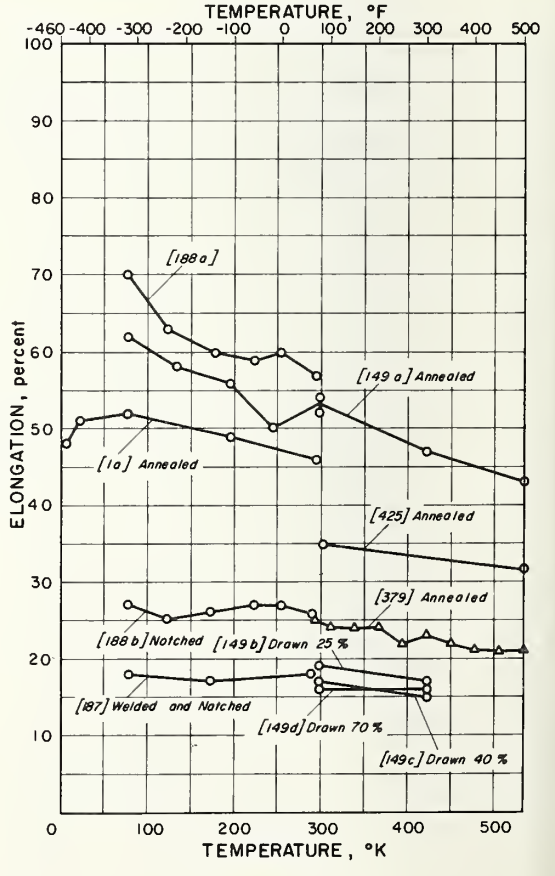
Tensile and Yield Strength of 70Cu-30Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed - 0.036mm. G.S. - R_B = 47. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, Y.S. - 0.2% offset.	68.6				30.1	0.7Mn, 0.6Fe	1
1b	Annealed - 0.036mm. G.S. - R_B = 47. Notched sample: 0.25 inch diam. at roots - 0.005 ± 0.0005 inch radius (K_T = 5.0), crosshead speed = 0.02 inch/minute.	68.6				30.1	0.7Mn, 0.6Fe	1
118	Annealed - after hot working. Bar sample - 0.505 inch reduced diam.	68.8	0.1			29.9	0.6Mn, 0.5Fe	118
149a	Annealed - 0.040mm. G.S. Bar sample - reduced section 2 inches long X 0.505 inch diam., strain rate = 0.01 inch/inch/minute, Y.S. - 0.2% offset.	68.8	0.1			29.9	0.6Mn, 0.5Fe	149
149b	Cold drawn 25%. Other specifications same as 149a.	68.8	0.1			29.9	0.6Mn, 0.5Fe	149
149c	Cold drawn 40%. Other specifications same as 149a.	68.8	0.1			29.9	0.6Mn, 0.5Fe	149
149d	Cold drawn 70%. Other specifications same as 149a.	68.8	0.1			29.9	0.6Mn, 0.5Fe	149
187	Welded plate supplied - parent: 70Cu-30Ni; filler composition given, edge preparation: double V - 60° included angle - feather edge - 1/16 inch root gap, plates butt welded - weld deposits prepared by argon shielded arc - consumable electrode; D.C. welding current = 350 amps.; welding speed = 4 to 6 inches/minute. Notched sample: 0.79 inch thick - assumed 0.76 inch between notches - approx. 0.01 inch notch radius (K_T = 6.2) - 45° included angle (Tipper notch).	64.8				33.5	0.6Mn, 0.5Fe, 0.2Ti, 0.2Si, 0.1Mg	187
188a	Plate sample - 0.625 inch thick X 0.515 inch wide.	69.0	0.1			30.6	0.2Fe, 0.2Mn	188
188b	Notched plate sample: 0.790 inch thick - 0.515 inch between notches - approx. 0.01 inch notch radius (K_T ≈ 5.1) - 45° included angle (Tipper notch).	69.0	0.1			30.6	0.2Fe, 0.2Mn	188
379	Annealed (stress-relief) - after drawing, bar supplied - 3/4 inch diam. Bar sample - 0.505 inch diam., strain rate = 0.001 inch/inch/minute to Y.S. - 0.05 inch/inch/minute to fracture, 3 tests/temp. except 2 tests at 75°F, 75 to 300°F - immersed in heated oil - above 300°F: furnace, Y.S. - 0.2% offset.	70.0				29.1	0.5Fe, 0.4Mn	379
425	Annealed - 0.007mm. G.S., bar supplied - 1 inch diam. Bar sample - 0.357 inch diam., strain rate = 0.1 inch/inch/minute, Y.S. - 0.5% strain.	68.0				30.8	0.6Fe, 0.4Mn	425



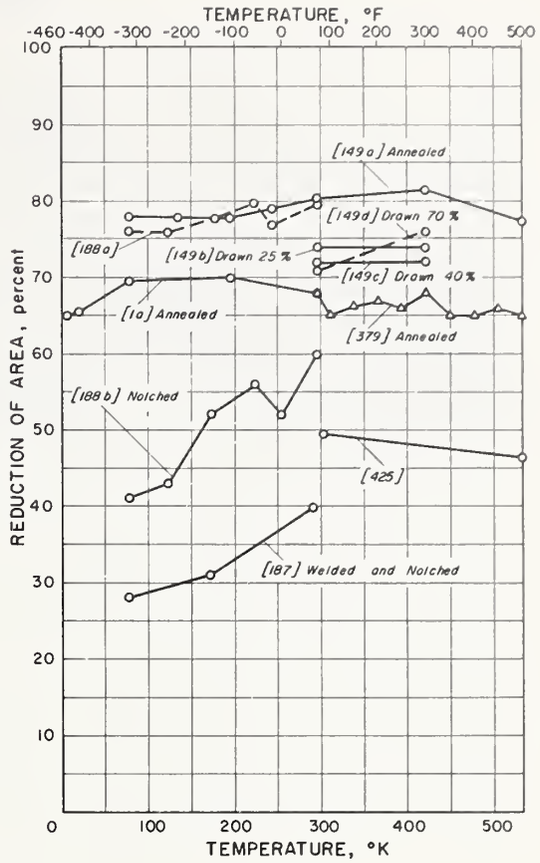
Tensile Elongation of 70Cu-30Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed - 0.036mm. G.S. - R_B = 47. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, 1 inch G.L.	68.6				30.1	0.7Mn, 0.6Fe	1
149a	Annealed - 0.040mm. G.S. Bar sample - reduced section - 2 inches long X 0.505 inch diam., strain rate ≈ 0.01 inch/inch/minute.	68.8	0.1			29.9	0.6Mn, 0.5Fe	149
149b	Cold drawn 25%. Other specifications same as 149a.	68.8	0.1			29.9	0.6Mn, 0.5Fe	149
149c	Cold drawn 40%. Other specifications same as 149a.	68.8	0.1			29.9	0.6Mn, 0.5Fe	149
149d	Cold drawn 70%. Other specifications same as 149a.	68.8	0.1			29.9	0.6Mn, 0.5Fe	149
187	Welded plate supplied - parent: 70Cu-30Ni; filler composition given, edge preparation: double V - 60° included angle - feather edge - 1/16 inch root gap, plates butt welded - weld deposits prepared by argon shielded arc - consumable electrode; D.C. welding current = 350 amps.; welding speed = 4 to 6 inches/minute. Notched sample: 0.79 inch thick - assumed 0.76 inch between notches - approx. 0.01 inch notch radius (K_T ≈ 6.2) - 45° included angle (Tipper notch), 2 inch G.L.	64.8				33.5	0.6Mn, 0.5Fe, 0.2Ti, 0.2Si, 0.1Mg	187
188a	Plate sample - 0.625 inch thick X 0.515 inch wide, 1.5 inch G.L.	69.0	0.1			30.6	0.2Fe, 0.2Mn	188
188b	Notched plate sample: 0.790 inch thick - 0.515 inch between notches - approx. 0.01 inch notch radius (K_T ≈ 5.1) - 45° included angle (Tipper notch), 2 inch G.L.	69.0	0.1			30.6	0.2Fe, 0.2Mn	188
379	Annealed (stress-relief) - after drawing, bar supplied - 3/4 inch diam. Bar sample - 0.505 inch diam., strain rate ≈ 0.001 inch/inch/minute to Y.S. - 0.05 inch/inch/minute to fracture, 3 tests/temp. except 2 tests at 75°F, 75 to 300°F - immersion in heated oil - above 300°F: furnace, 2 inch G.L.	70.0				29.1	0.5Fe, 0.4Mn	379
425	Annealed - 0.007mm. G.S., bar supplied - 1 inch diam. Bar sample - 0.357 inch diam., strain rate ≈ 0.1 inch/inch/minute, 2 inch G.L.	68.0				30.8	0.6Fe, 0.4Mn	425



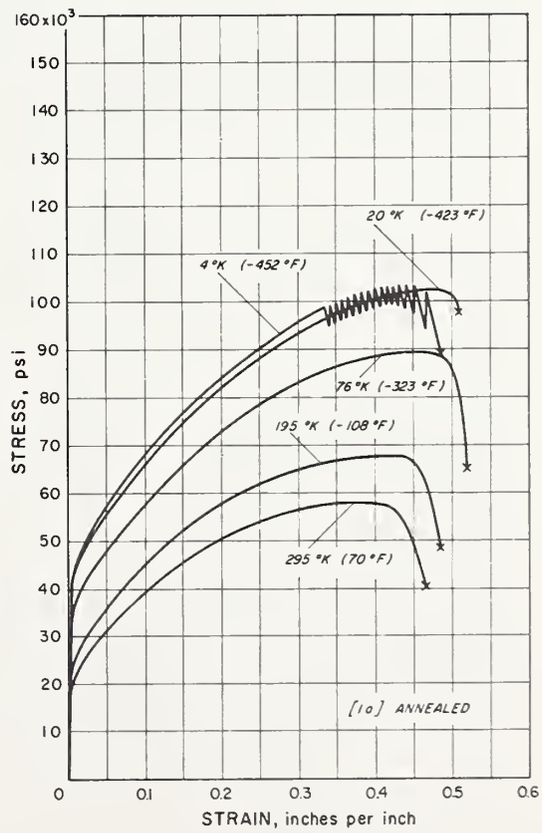
Tensile Reduction of Area of 70Cu-30Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed - 0.036mm. G.S. - R_B = 47. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam. crosshead speed = 0.02 inch/minute.	68.6				30.1	0.7Mn, 0.6Fe	1
149a	Annealed - 0.040mm. G.S. bar sample - reduced section - 2 inches long X 0.505 inch diam., strain rate ≈0.01 inch/inch/minute.	68.8	0.1			29.9	0.6Mn, 0.5Fe	149
149b	Cold drawn 25%. Other specifications same as 149a.	68.8	0.1			29.9	0.6Mn, 0.5Fe	149
149c	Cold drawn 40%. Other specifications same as 149a.	68.8	0.1			29.9	0.6Mn, 0.5Fe	149
149d	Cold drawn 70%. Other specifications same as 149a.	68.8	0.1			29.9	0.6Mn, 0.5Fe	149
187	Welded plate supplied - parent: 70Cu-30Ni; filler composition given, edge preparation - double V-60° included angle - feather edge - 1/16 inch root gap, plates butt welded - weld deposits prepared by argon shielded arc - consumable electrode; D.C. welding current = 350 amps, welding speed = 4 to 6 inches/minute. Notched sample: 0.79 inch thick - assumed 0.76 inch between notches - approx. 0.01 inch notch radius ($K_T \approx 6.2$) - 45° included angle (Tipper notch).	64.8				33.5	0.6Mn, 0.5Fe, 0.2Ti, 0.2Si, 0.1M_8	187
188a	Plate sample - 0.625 inch thick X 0.515 inch wide.	69.0	0.1			30.6	0.2Fe, 0.1Mn	188
188b	Notched plate sample: 0.790 inch thick - 0.515 inch between notches - approx. 0.01 inch notch radius ($K_T \approx 5.1$) - 45° included angle (Tipper notch).	69.0	0.1			30.6	0.2Fe, 0.1Mn	188
379	Annealed (stress-relief) - after drawing, bar supplied - 3/4 inch diam. Bar sample - 0.505 inch diam., strain rate ≈0.001 inch/inch/minute to Y.S. - 0.05 inch/inch/minute to fracture, 3 tests/temp. except 2 at 75°F, 75 to 300°F - immersion in heated oil - above 300°F: furnace.	70.0				29.1	0.5Fe, 0.4Mn	379
425	Annealed - 0.007mm. G.S., bar supplied - 1 inch diam. Bar sample - 0.357 inch diam., strain rate ≈0.1 inch/inch/minute.	68.0				30.8	0.6Fe, 0.4Mn	425



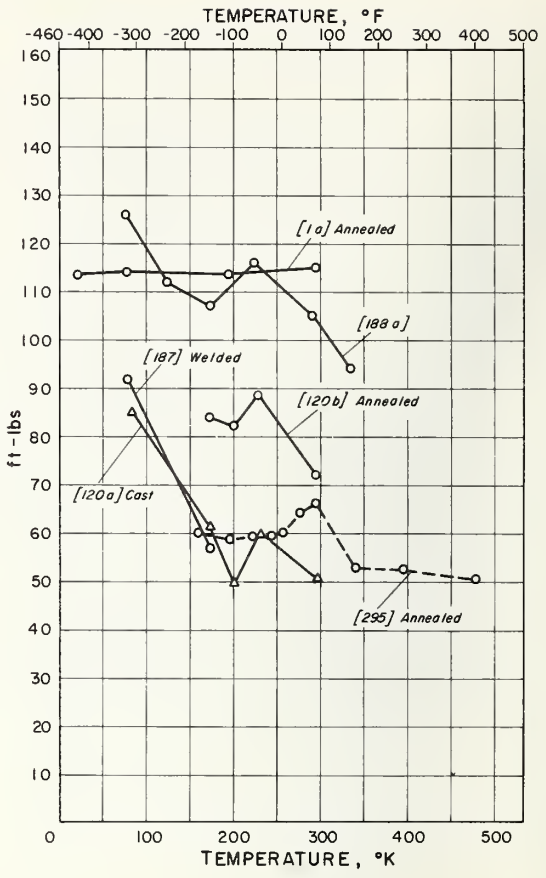
Tensile Stress-Strain Curves of 70Cu-30Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed - 0.036mm. G.S. - R_B = 47, bar supplied - 3/4 inch diam. Bar sample - reduced section 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer, 1 inch G.L.	68.7				30.0	0.7Mn, 0.6Fe	1



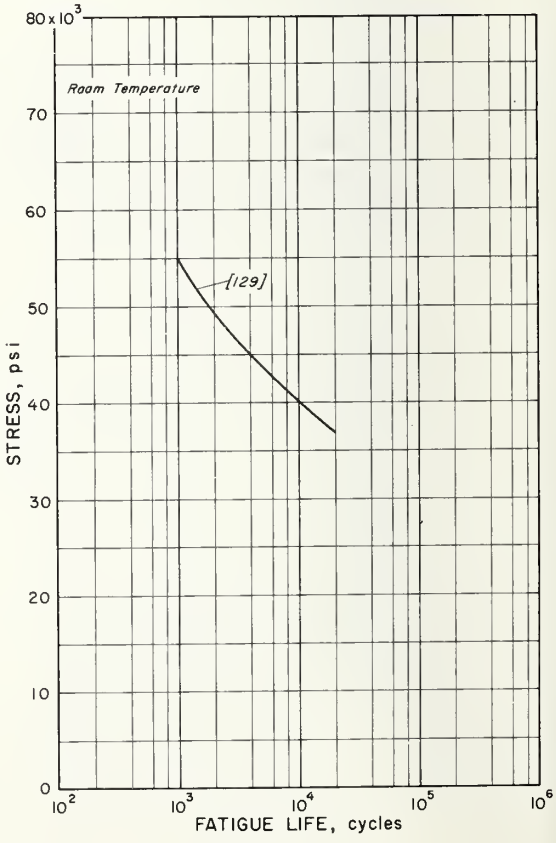
Impact Energy of 70Cu-30Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
1a	Annealed - 0.036mm. G.S. - R_B = 47. Charpy V-notch, 60% fracture area - all temps.	68.6				30.1	0.7Mn, 0.6Fe	1
120a	As cast - Brinell hardness = 65 to 74. Charpy keyhole.	68.9				30.6		120
120b	Annealed - wrought bar - Brinell hardness = 92. Charpy keyhole.	68.9				30.6		120
187	Welded plate supplied - parent: 70Cu-30Ni; filler composition given, edge preparation: double V - 60° included angle - feather edge - 1/16 inch root gap, plate butt welded - weld deposits prepared by argon shielded arc - consumable electrode; D.C. welding current = 350 amps.; welding speed = 4 to 6 inches/minute. Charpy V-notch.	64.8				33.5	0.6Mn, 0.5Fe 0.2Ti, 0.2Si, 0.1Mg	187
188a	Charpy V-notch.	69.0	0.1			30.6	0.2Fe, 0.1Mn	188
295	Annealed - R_B = 55. Charpy keyhole, all samples - partial fracture, 3 tests/temp.	69.3	0.6			29.5	0.6Mn	295



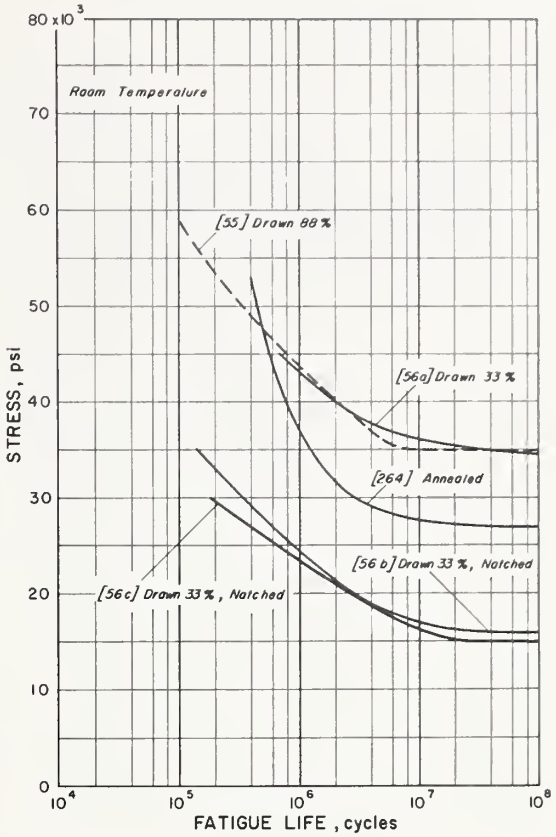
Fatigue Behavior of 70Cu-30Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
129	Room temp.: U.T.S. = 58,000 psi - Y.S. = 20,000 psi (0.2% offset), plate supplied - 1 inch thick. Plate sample - 2-1/4 inch radius reduced section - 2-1/2 inches wide X 0.5 inch reduced thickness, flexure cantilever - square wave load pattern, R = -1.	68.6	0.2			29.6	0.9Mn, 0.6Fe	129



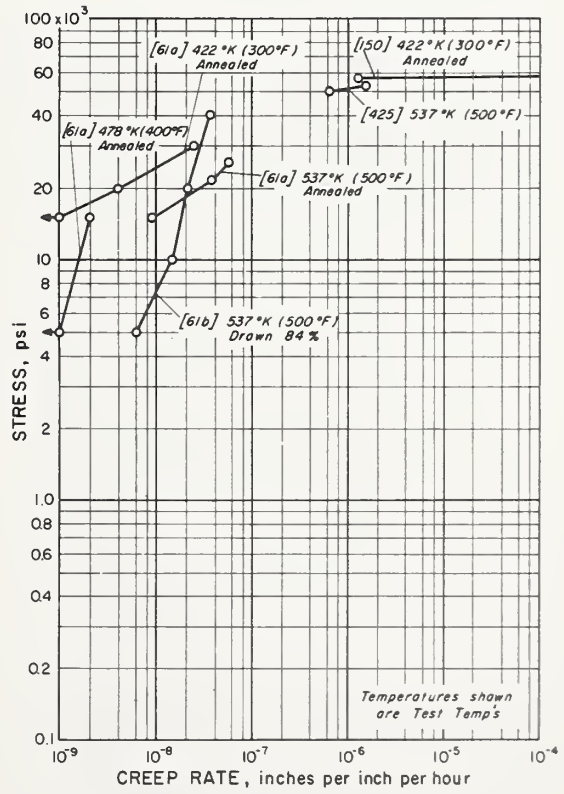
Fatigue Behavior of 70Cu-30Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
55	Drawn 88%, room temp.: U.T.S. = 96,200 psi - Y.S. = 89,500 psi (0.2% offset). Wire sample - 0.072 inch diam., rotating arc - 3450 r.p.m., R = -1, sample at 34,500 psi - 3 X 10^7 cycles did not break.	70.2				29.1	0.5Mn	55
56a	Drawn 33% - 0.025mm. G.S. Bar sample - 0.3 inch reduced diam., rotating cantilever - 8000 r.p.m.	68.0				30.7	0.5Mn, 0.5Fe, 0.2Zn	56
56b	Notched bar: 0.30 inch diam. at notch - 0.015 inch notch radius (K_T = 3.16) - 60°. Other specifications same as 56a.	68.0				30.7	0.5Mn, 0.5Fe, 0.2Zn	56
56c	Notched bar: 0.30 inch diam. at notch - 0.0006 inch notch radius (K_T = 15.8). Other specifications same as 56a.	68.0				30.7	0.5Mn, 0.5Fe, 0.2Zn	56
264	Annealed 800°C - 2 hrs. prior to finishing, R_B = 90, T.S. = 97,900 psi. Sheet sample - 0.025 inch thick. Townsend and Greenall flexure, reciprocating arm machine, 800 rpm, R = -1.	68.5		1.3		29.6	0.2Fe, 0.3Mn	264



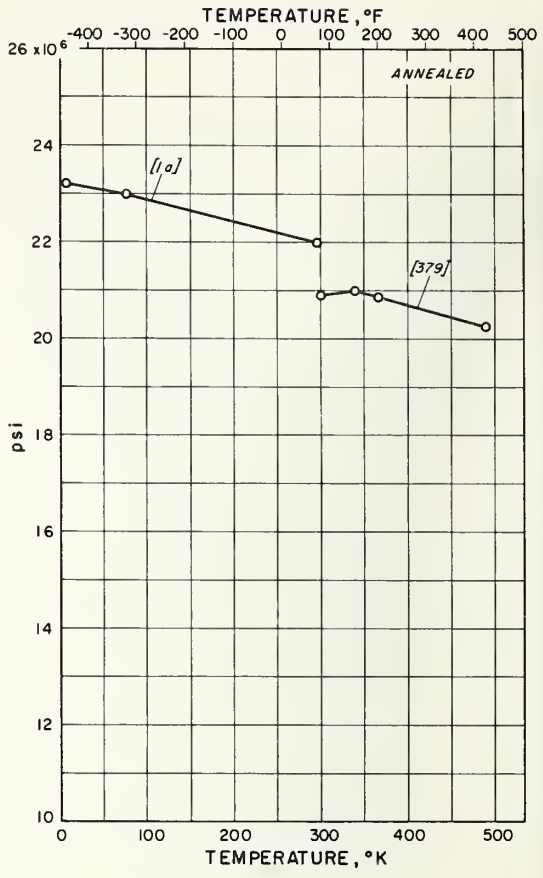
Creep Behavior of 70Cu-30Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
61a	Annealed - 0.020mm. G.S., room temp.: Y.S. = 21,000 psi (0.5% strain). Bar sample - 0.125 inch diam., second stage creep, 10 inch G.L.	69.1				30.1	0.8Mn	61
61b	Drawn 84%. Bar sample - 0.125 inch diam., 10 inch G.L.	69.1				30.1	0.8Mn	61
150	Annealed - 0.040mm. G.S. Bar sample - 0.505 inch diam. Second stage creep, no creep to 47,200 psi., 2 inch G.L.	68.8	0.1			29.9	0.5Fe, 0.6Mn	150
425	Annealed - 0.007mm. G.S., 500°F; U.T.S. = 64,100 psi - Y.S. = 32,000 psi (0.5% strain), bar supplied - 1 inch diam. Bar sample - 0.357 inch diam. - 1.8 inch G.L., second stage creep.	68.0				30.8	0.6Fe, 0.4Mn	425



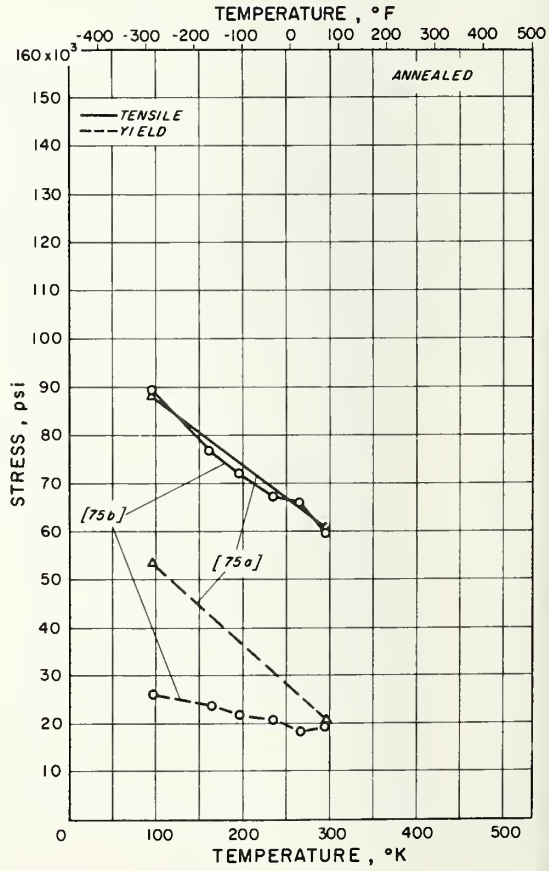
Modulus of Elasticity of 70Cu-30Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed - 0.036mm. G.S. - R_B = 47. Bar sample - reduced section - 1.5 inches long X 0.250 inch diam., crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer, 1 inch G.L.	68.6				30.1	0.7Mn, 0.6Fe	1
379	Annealed (stress-relief) - after drawing, bar supplied - 3/4 inch diam. Bar sample - 0.250 inch diam., dynamic modulus - transverse vibrations.	70.0				29.1	0.5Fe, 0.4Mn	379



Tensile and Yield Strength of 55Cu-45Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
75a	Annealed - after rolling. Bar sample - 0.504 inch diam., Y.S. at 70°F - 0.1% offset; Y.S. at - 292°F by drop of beam.	54.4				44.8	0.3Mn, 0.2Co 0.2Si, 0.1Fe	75
75b	Annealed - after rolling. Bar sample - 0.25 inch diam., Y.S. - 0.1% offset.	54.4				44.8	0.3Mn, 0.2Co 0.2Si, 0.1Fe	75

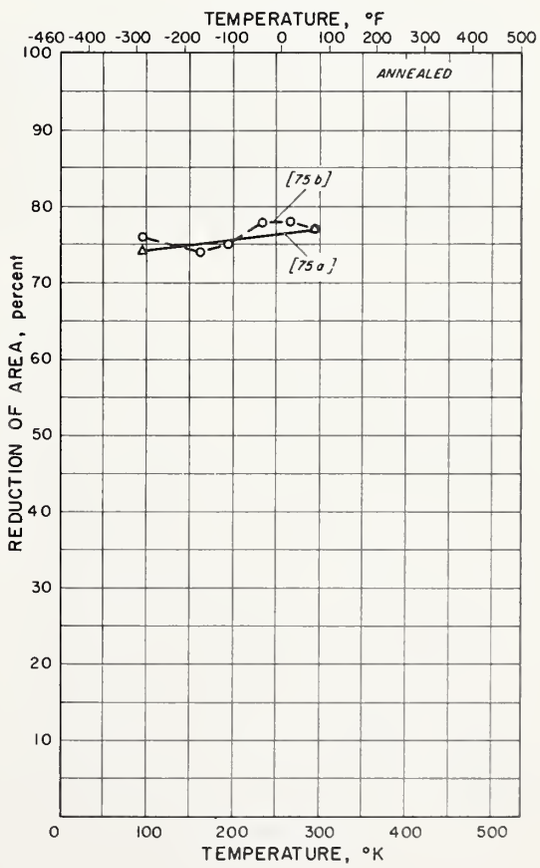


Tensile Elongation of 55Cu-45Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
75a	Annealed - after rolling. Bar sample - 0.504 inch diam., 2 inch G. L.	54.4				44.8	0.3Mn, 0.2Co, 0.2Si, 0.1Fe	75
75b	Annealed - after rolling. Bar sample - 0.25 inch diam., 2 inch G. L.	54.4				44.8	0.3Mn, 0.2Co, 0.2Si, 0.1Fe	75

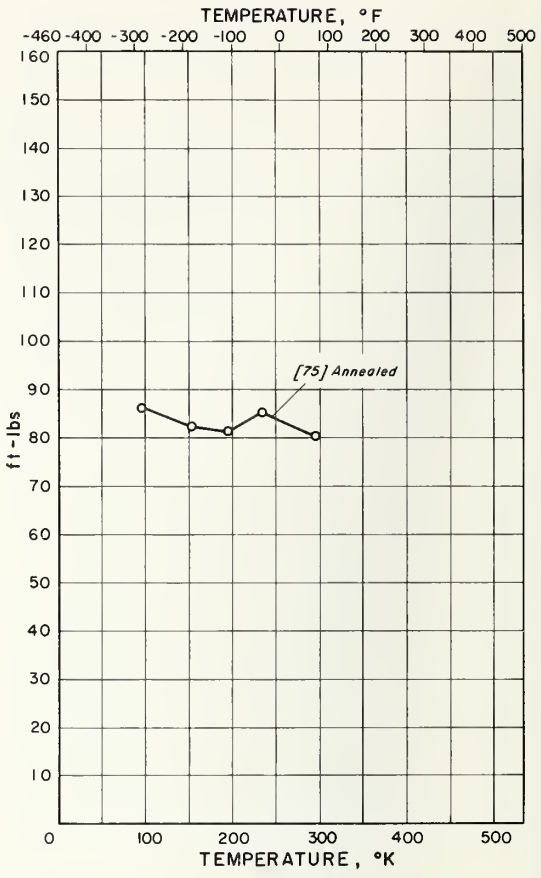
Tensile Reduction of Area of 55Cu-45Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
75a	Annealed - after rolling. Bar sample - 0.504 inch diam.	54.4				44.8	0.3Mn, 0.2Co, 0.2Si, 0.1Fe	75
75b	Annealed - after rolling. Bar sample - 0.25 inch diam.	54.4				44.8	0.3Mn, 0.2Co, 0.2Si, 0.1Fe	75



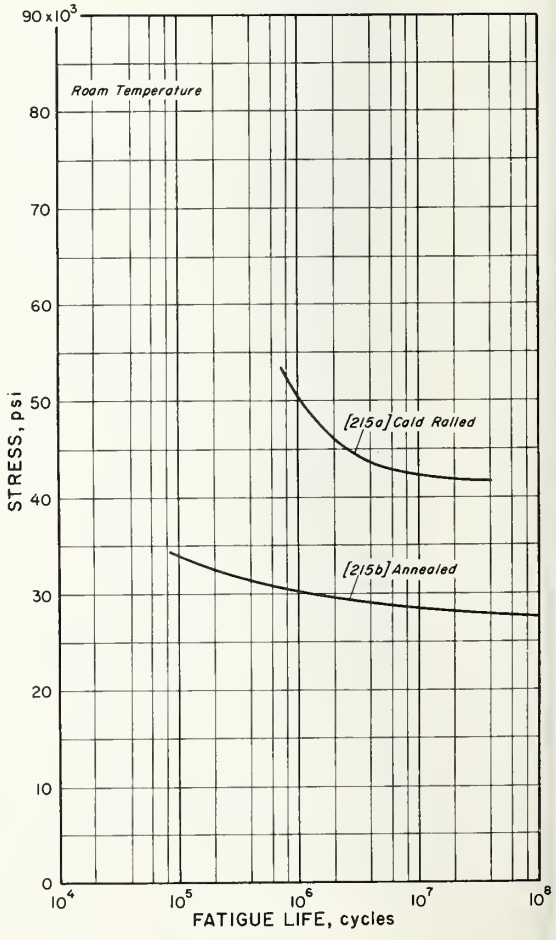
Impact Energy of 55Cu-45Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
75	Annealed - after rolling. Izod.	54.4				44.8	0.3Mn, 0.2Co, 0.2Si, 0.1Fe	75



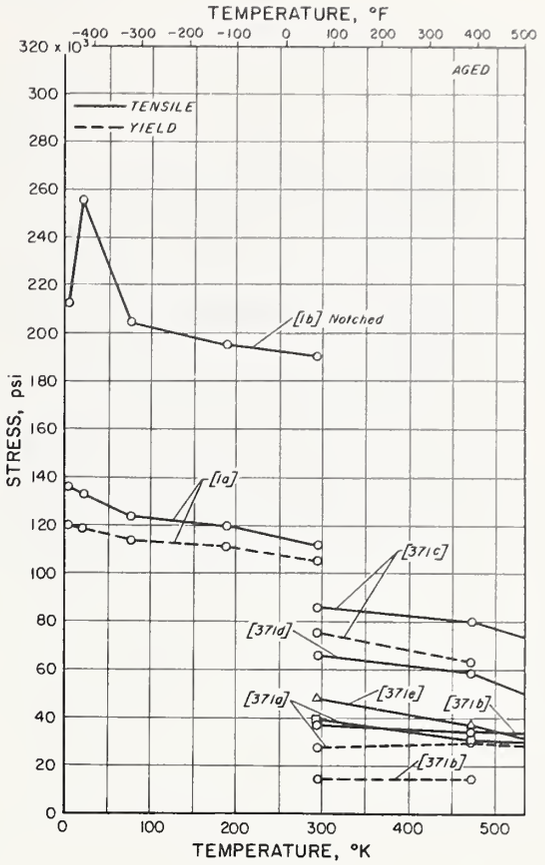
Fatigue Behavior of 55Cu-45Ni

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
215a	Cold rolled, room temp.: U.T.S. = 103,300 psi - Y.S. = 54,700 psi. Bar sample - reduced section: 2 inches long - approx. 0.5 inch diam. at ends - 0.463 inch diam. near center, rotating cantilever.	53.7				44.8	0.8Mn, 0.6Fe 0.1C	215
215b	Annealed, room temp.: U.T.S. = 69,400 psi - Y.S. = 25,400 psi. Other specifications same as 215a.	53.7				44.8	0.8Mn, 0.6Fe 0.1C	215



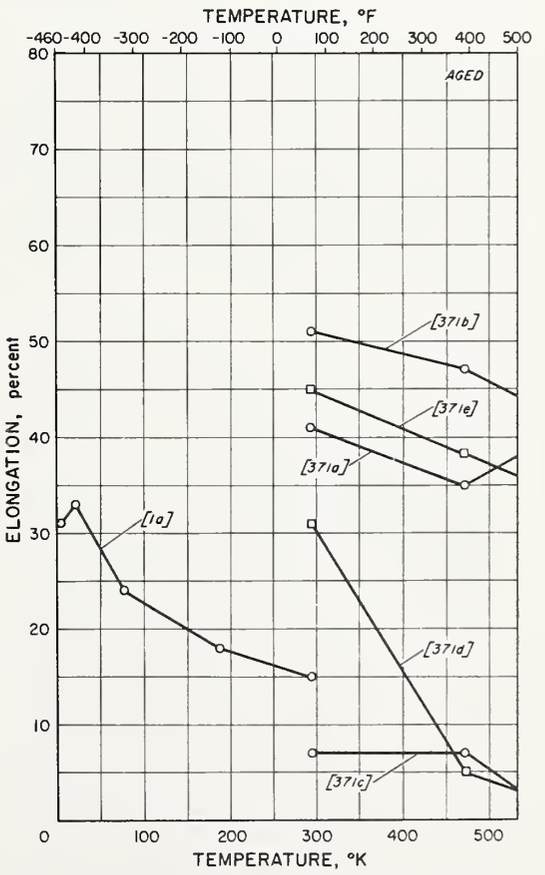
Tensile and Yield Strength of Cu-Ni-Si

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
1a	Aged 450°C - 2 hrs. - 0.025mm. G.S. - R_B = 98, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, Y.S. - 0.2% offset.	Bal				2.0	0.5Si	1
1b	Notched sample: 0.250 inch diam. at notch - 0.005 ± 0.0005 inch notch radius (K_T = 5.0). Other specifications same as 1a.	Bal				2.0	0.5Si	1
371a	Heated - 900°C - 2 hrs., water quenched - reheated to 900°C - cooled to 200°C during 7 weeks - Brinnell hardness = 63 (40 kgm.), 1/2 inch plate supplied - rolled 75%. Bar sample - 0.226 inch diam., Y.S. - 0.2% offset.	96.3				2.5	0.6Si, 0.5Mn	371
371b	Heated - 900°C - 2 hrs., water quenched - reheated to 900°C - water quenched - Brinnell hardness = 60 (40 kgm.) 1/2 inch plate supplied - rolled 75%. Bar sample - 0.226 inch diam., Y.S. - 0.2% offset.	96.3				2.5	0.6Si, 0.5Mn	371
371c	Heated - 900°C - 2 hrs., water quenched - reheated to 900°C - water quenched - reheated 2 hrs. at 500°C - Brinell hardness = 178 (40 kgm.), 1/2 inch plate supplied - rolled 75%. Bar sample - 0.226 inch diam., Y.S. - 0.2% offset.	96.3				2.5	0.6Si, 0.5Mn	371
371d	Heated 900°C - 2 hrs. - water quenched - reheated 900°C - water quenched - reheated 425°C, 1/2 inch plate supplied - rolled 75%. Bar sample - 0.226 inch diam.	96.5				2.4	0.6Si, 0.4Mn	371
371e	Heated 900°C - 2 hrs. - water quenched - reheated 900°C - water quenched - reheated 700°C, 1/2 inch plate supplied - rolled 75%. Bar sample - 0.226 inch diam.	96.5				2.4	0.6Si, 0.4Mn	371



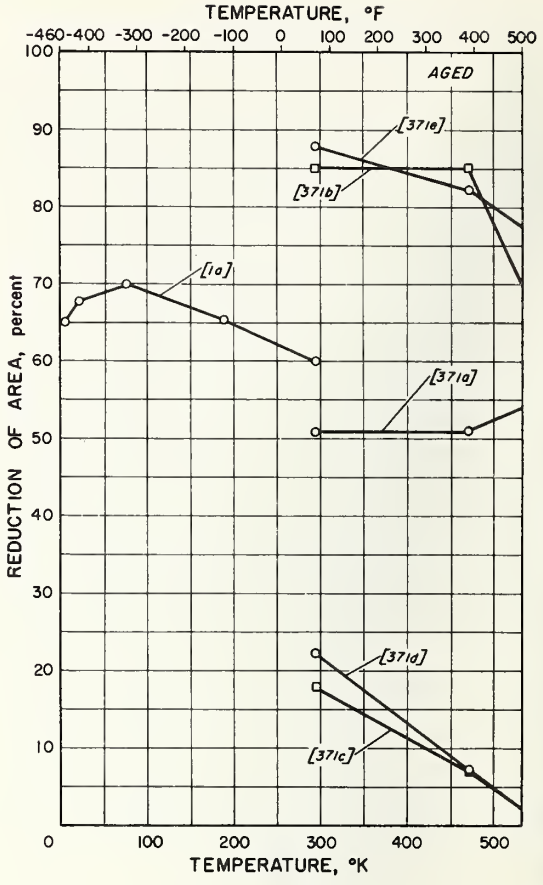
Tensile Elongation of Cu-Ni-Si

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
1a	Aged 450°C - 2 hrs. - 0.025mm. G.S. - R_B = 98, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, 1 inch C.L. (4 X diam.).	Bal				2.0	0.5Si	1
371a	Heated 900°C - 2 hrs. - water quenched - reheated to 900°C - cooled to 200°C in 7 weeks - Brinell hardness = 63 (40 kgm.), 1/2 inch plate supplied - rolled 75%. Bar sample - 0.226 inch diam., 1 inch C.L.	96.3				2.5	0.6Si, 0.5Mn	371
371b	Heated 900°C - 2 hrs. - water quenched - reheated to 900°C - water quenched - Brinell hardness = 60 (40 kgm.) - 1/2 inch plate supplied - rolled 75%. Bar sample - 0.226 inch diam., 1 inch C.L.	96.3				2.5	0.6Si, 0.5Mn	371
371c	Heated 900°C - 2 hrs. - water quenched - reheated to 900°C - water quenched - reheated 500°C - 2 hrs. - Brinell hardness = 178 (40 kgm.) - 1/2 inch plate supplied - rolled 75%. Bar sample - 0.226 inch diam., 1 inch C.L.	96.3				2.5	0.6Si, 0.5Mn	371
371d	Heated 900°C - 2 hrs. - water quenched - reheated 900°C - water quenched - reheated 425°C, 1/2 inch plate supplied - rolled 75%. Bar sample - 0.226 inch diam., 1 inch C.L.	96.5				2.4	0.6Si, 0.4Mn	371
371e	Heated 900°C - 2 hrs. - water quenched - reheated 900°C - water quenched - reheated 700°C, 1/2 inch plate supplied - rolled 75%. Bar sample - 0.226 inch diam., 1 inch G.L.	96.5				2.4	0.6Si, 0.4Mn	371



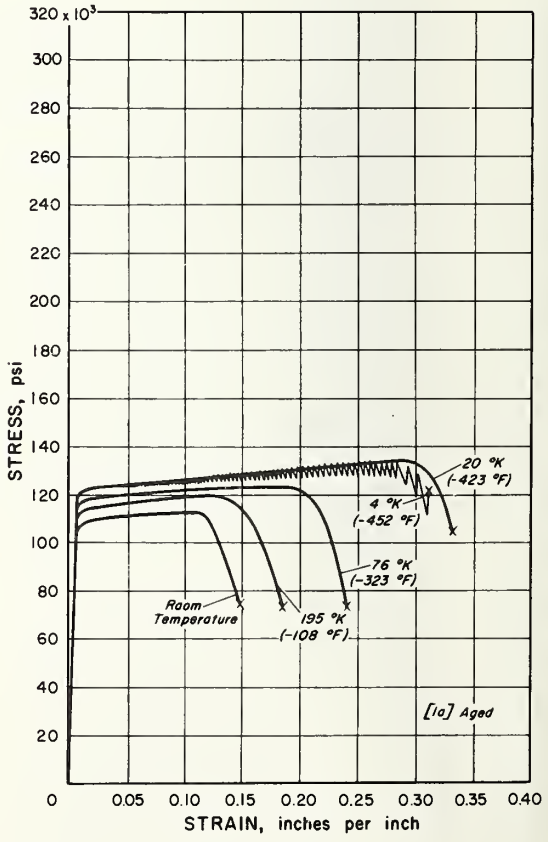
Tensile Reduction of Area of Cu-Ni-Si

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Aged 450°C - 2 hrs - 0.025mm G.S. - R_B = 98, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute.	Bal				2.0	0.5Si	1
371a	Heated 900°C - 2 hrs. - water quenched - reheated 900°C - cooled to 200°C in 7 weeks - Brinell hardness = 63 (40 kgm.), 1/2 inch plate supplied - rolled 75%. Bar sample - 0.266 inch diam.	96.3				2.5	0.6Si, 0.5Mn	371
371b	Heated 900°C - 2 hrs. - water quenched - reheated 900°C - water quenched - Brinell hardness = 60 (40 kgm.), 1/2 inch plate supplied - rolled 75%. Bar sample - 0.226 inch diam.	96.3				2.5	0.6Si, 0.5Mn	371
371c	Heated 900°C - 2 hrs. - water quenched - reheated 900°C - water quenched - reheated 500°C - 2 hrs. - Brinell hardness = 178 (40 kgm.), 1/2 inch plate supplied - rolled 75%. Bar sample - 0.266 inch diam.	96.3				2.5	0.6Si, 0.5Mn	371
371d	Heated 900°C - 2 hrs. - water quenched - reheated 900°C - water quenched - reheated 425°C., 1/2 inch plate supplied - rolled 75%. Bar sample - 0.226 inch diam.	96.5				2.4	0.6Si, 0.4Mn	371
371e	Heated 900°C - 2 hrs. - water quenched - reheated 900°C - water quenched - reheated 700°C, 1/2 inch plate supplied - rolled 75%. Bar sample - 0.226 inch diam.	96.5				2.4	0.6Si, 0.4Mn	371



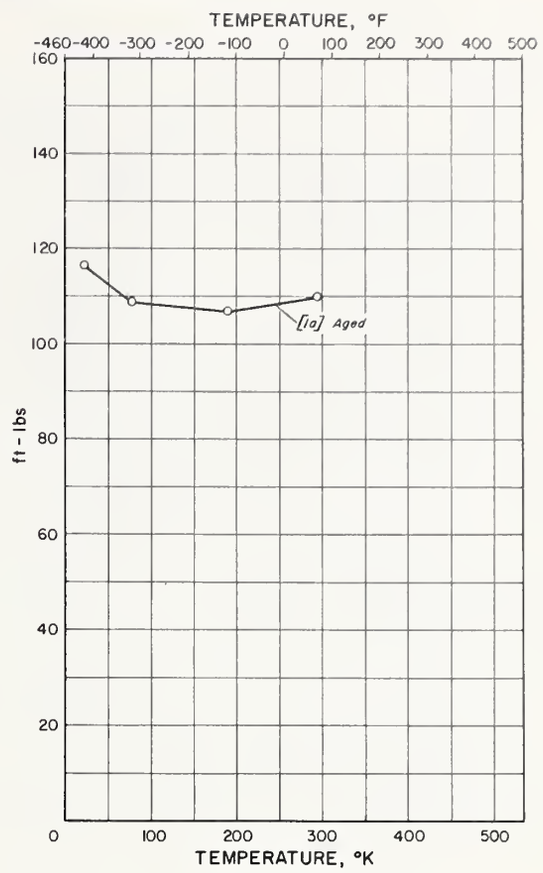
Tensile Stress-Strain Curves of Cu-Ni-Si

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Aged 450°C - 2 hrs. - 0.025mm. G.S. - R_B = 98, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer - 1 inch G.L.	Bal				2.0	0.5Si	1



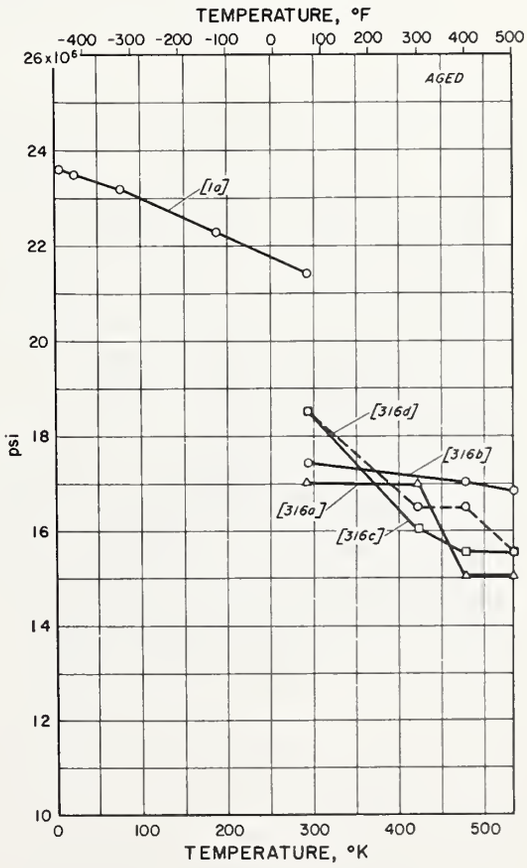
Impact Energy of Cu-Ni-Si

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Aged 450°C - 2 hrs. - 0.025mm. G.S. - R_B = 98, bar supplied - 3/4 inch diam. Charpy V-notch, 90% fracture at 295 and 195°K; 50% at 76°K; 25% at 20°K, hammer velocity = 16 ft./sec., paper boat container glued to sample for 20°K tests.	Bal				2.0	0.5Si	1



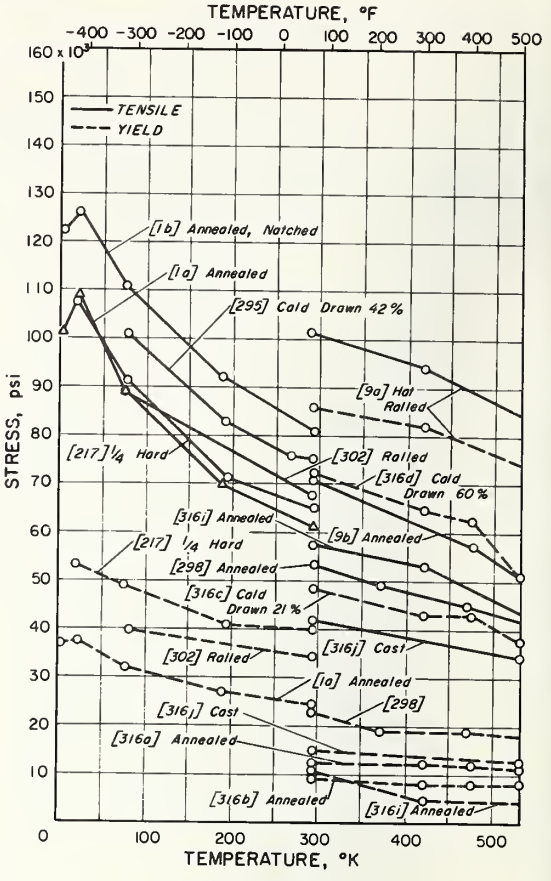
Modulus of Elasticity of Cu-Ni-Si

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Aged 450°C - 2 hrs. - 0.020mm. G.S. - R_B = 98, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.250 inch diam., clamp-on strain gage extensometer - 1 inch G.L.	Bal				2.0	0.5Si	1
316a	Aged 850°F - 4 hrs. - after heating 1450°F and quenching. Bar sample - 0.125 inch diam.	98.6				1.2	0.2P	316
316b	Cold drawn, bar supplied - 3/4 inch diam.	98.3				1.1	0.3P, 0.3Te	316
316c	Aged 850°F - 1 1/2 hrs. - after heating 1450°F and quenching. Bar sample - 0.125 inch diam.	98.1				1.1	0.3P, 0.5Te	316
316d	Aged 750°F - 1 1/2 hrs. - after heating 1450°F and quenching - then drawing 30%. Bar sample - 0.125 inch diam.	98.1				1.1	0.3P, 0.5Te	316



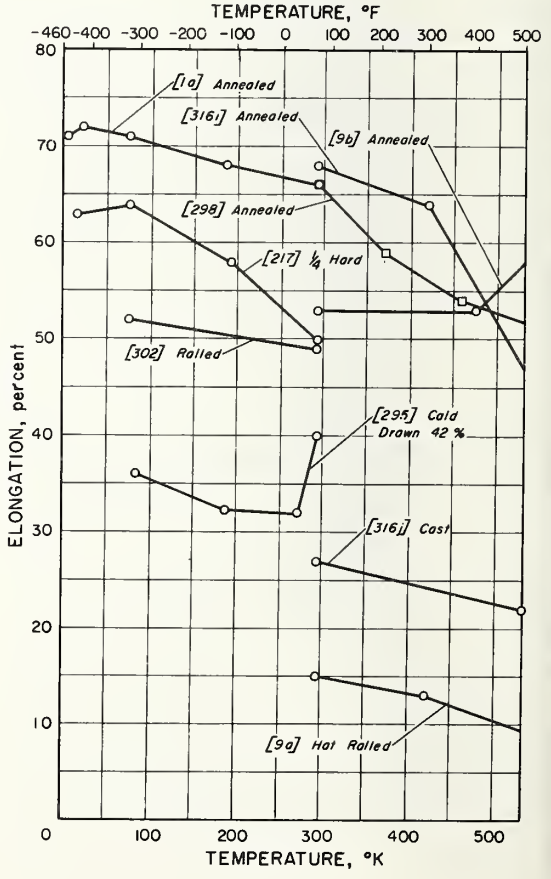
Tensile and Yield Strength of Cu-Si (Silicon Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed (soft) - 0.025mm. G.S. - R_B = 54, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, Y.S. - 0.2% offset.	Bal					2.9Si, 0.1Fe 0.9Mn	1
1b	Notched sample - 0.25 inch diam. at notch - 0.005 ± 0.0005 inch notch radius ($K_T \approx 5.0$). Other specifications same as 1a.	Bal					2.9Si, 0.9Mn, 0.1Fe	1
9a	Hot rolled - Brinell hardness = 182, bar supplied - 3/4 inch diam., Y.S. - 0.2% offset.	95.3					3.4Si, 1.2Mn, 0.1Fe	9
9b	Annealed 842°F - R_B = 75 - 3/4 inch cold drawn bar supplied.	95.6					2.8Si, 1.2Mn, 0.2Fe	9
217	1/4 hard - R_B = 78, 1/8 inch sheet supplied. Sample cut longitudinally, crosshead speed = 0.2 inches/minute, Y.S. - 0.2% offset.	95.8					3.1Si, 0.9Mn	217
295	Cold drawn 42% - after annealing. Bar sample - 0.25 inch diam. (0.5 inch diam. for 77°F), loading speed ≈20,000 psi/minute.	Bal					2.8Si, 1.0Mn, 0.2Fe	295
298	Annealed. Strip sample - 0.075 inch thick, held 15 minutes at test temp., crosshead speed = 2 inches/minute, Y.S. - 0.1% offset.	95	0.2				3.6Si, 1.0Mn	298
302	Rolled. Y.S. - 0.2% offset.	94.5					4.5Si, 1.0Mn	302
316a	Annealed - 0.025mm. G.S., wrought. Bar sample - 0.125 inch diam., Y.S. - 0.2% offset.	97.4	1.0				1.6Si	316
316b	Annealed - 0.060mm. G.S., wrought, Bar sample - 0.125 inch diam., Y.S. - 0.2% offset.	97.4	1.0				1.6Si	316
316c	Cold drawn 21%, wrought. Bar sample - 0.125 inch diam. 0.2% offset.	97.4	1.0				1.6Si	316
316d	Cold drawn 60%, wrought. Bar sample - 0.125 inch diam., Y.S. - 0.2% offset.	97.4	1.0				1.6Si	316
316i	Annealed 1500°F - Brinell hardness = 50 - after cold drawing, 3/4 inch diam., wrought bar supplied, Y.S. - 0.2% offset.	95.3					1.2Mn, 3.4 Si, 0.1Fe	316
316j	Cast (double keel blocks) - R_B = 52. Machined sample, Y.S. - 0.2% offset.	94.6					4.1Si, 0.9Mn	316



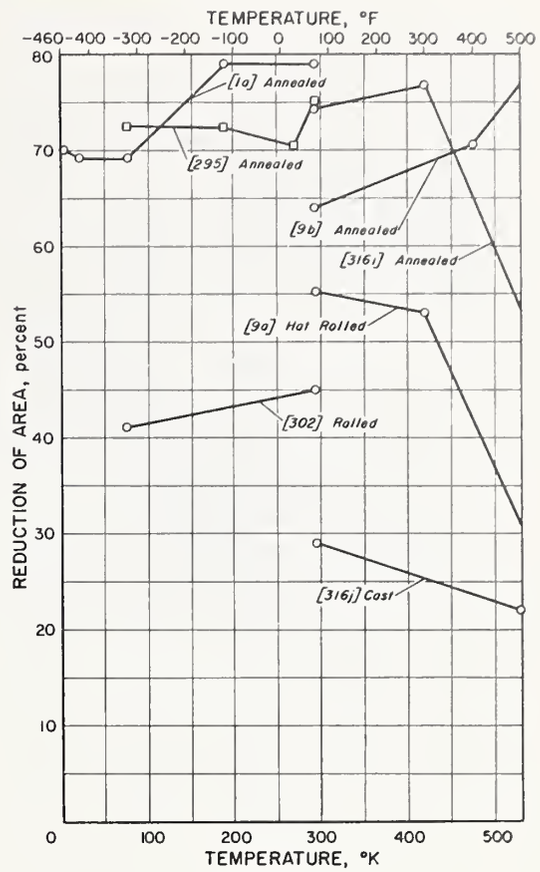
Tensile Elongation of Cu-Si (Silicon Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed (soft) - 0.025mm. G.S. - R_B = 54, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, 1 inch G.L.	Bal					2.9Si, 0.9Mn, 0.1Fe	1
9a	Hot rolled - Brinell hardness = 182, bar supplied - 3/4 inch diam., 1 inch G.L.	95.3					3.4Si, 1.2Mn, 0.1Fe	9
9b	Annealed 842°F - R_B = 75, 3/4 inch cold drawn bar supplied, 1 inch G.L.	95.6	0.2				2.8Si, 1.2Mn, 0.2Fe	9
217	1/4 hard - R_B = 78, 1/8 inch sheet supplied. Sample cut longitudinally, crosshead speed = 0.2 inch/minute, 1 inch G.L.	95.8					3.1Si, 0.9Mn	217
295	Cold drawn 42% - after annealing. Bar sample - 0.25 inch diam. (0.5 inch for 77°K), loading speed = 20,000 psi/minute, 1 inch G.L.	Bal					2.8Si, 0.2Fe, 1.0Mn	295
298	Annealed - 0.075 inch thick strip, held 15 minutes at test temp., crosshead speed = 2 inches/minute, 1 inch G.L.	95	0.2				3.6Si, 1.0Mn	298
302	Rolled. 1 inch G.L.	94.5					3.5Si, 1.0Mn	302
316i	Annealed 1500°F - Brinell hardness = 50 - after cold drawing, 3/4 inch diam. wrought bar supplied - 1 inch G.L.	95.3					3.4Si, 1.2Mn	316
316j	Cast (double keel blocks) - R_B = 52. Machined sample, 1 inch G.L.	94.6					4.1Si, 0.9Mn	316



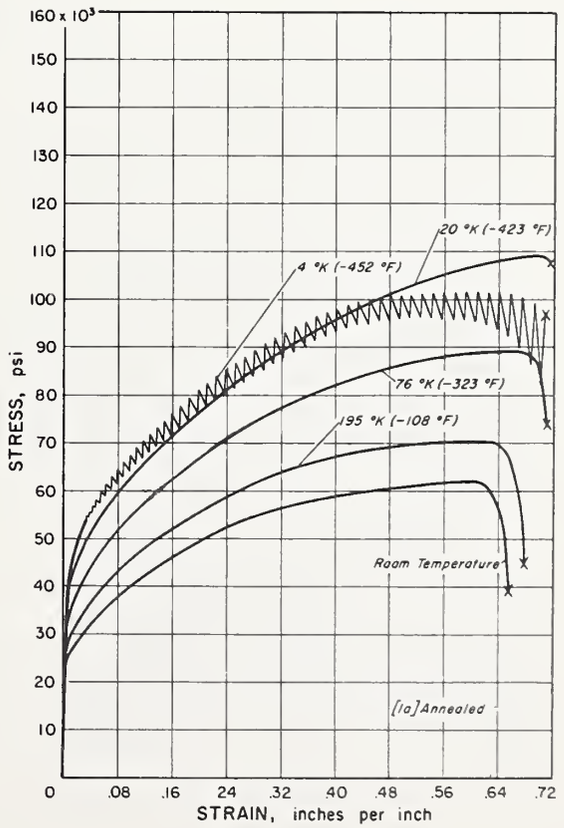
Tensile Reduction of Area of Cu-Si (Silicon Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed (soft) - 0.025mm. G.S. - R_B = 54, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch diam., crosshead speed = 0.02 inch/minute.	Bal					2.9Si, 0.9Mn, 0.1Fe	1
9a	Hot rolled - Brinell hardness = 182, bar supplied - 3/4 inch diam.	95.3					3.4Si, 1.2Mn, 0.1Fe	9
9b	Annealed 842°F - R_B = 75, 3/4 inch cold drawn bar supplied.	95.6	0.2				2.8Si, 1.2Mn, 0.2Fe	9
295	Cold drawn 42% - after annealing. Bar sample = 0.25 inch diam. (except 0.5 inch for 77°K), loading speed = 20,000 psi. minute.	Bal					2.8Si, 1.0Mn, 0.2Fe	295
302	Rolled.	94.5					1Mn, 4.5Si	302
316l	Annealed 1500°F - Brinell hardness = 50 - after cold drawing, 3/4 inch wrought bar supplied.	95.3					3.4Si, 1.2Mn, 0.1Fe	316
316j	Cast (double keel blocks) - R_B = 52. Machined sample.	94.6					4.1Si, 0.9Mn	316



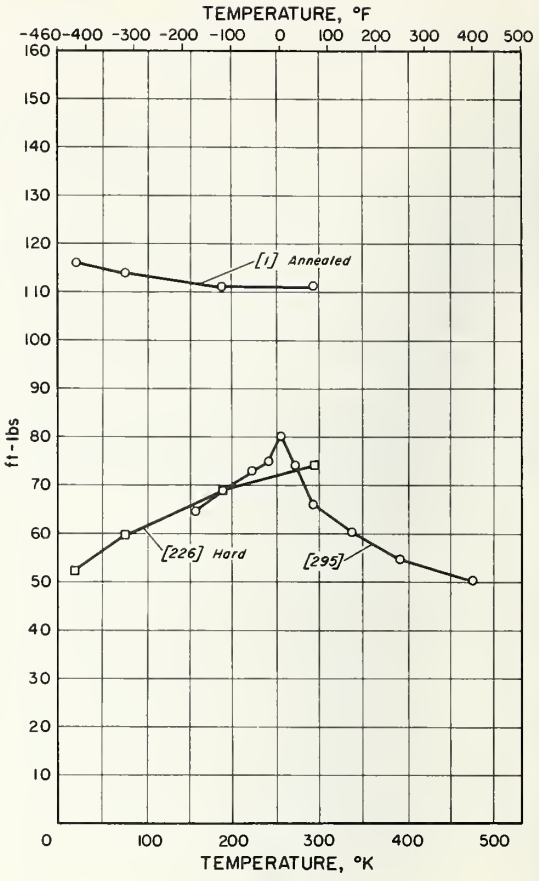
Tensile Stress-Strain Curves of Cu-Si (Silicon Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed (soft) - 0.025mm. G.S. - R_B = 54, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer, 1 inch G.L.	Bal					2.9Si, 0.9Mn 0.1Fe	1



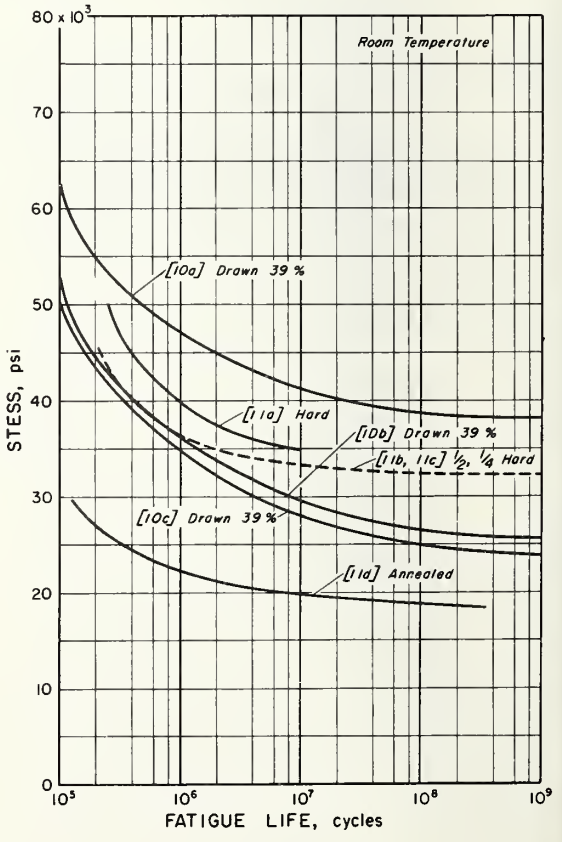
Impact Energy of Cu-Si (Silicon Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
1	Annealed (soft) - 0.025mm. G.S. - R_B = 54. Charpy V-notch, samples fractured only 5%.	Bal					2.9Si, 0.9Mn 0.1Fe	1
226	Hard - R_B = 91. Charpy V-notch.	Bal					3Si, 1Mn	226
295	Room temp.: U.T.S. = 62,400 psi - Y.S. = 29,900 psi (0.2% offset) - R_B = 54. Charpy keyhole, samples unfractured.	Bal					3.0Si, 0.2Fe, 1.0Mn	295



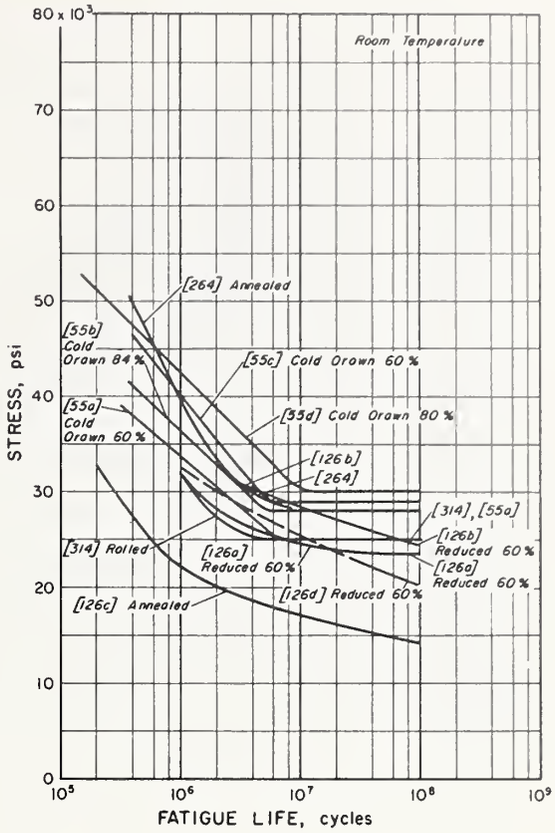
Fatigue Behavior of Cu-Si (Silicon Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
10a	Hard drawn 39% - R_B = 98 - after 0.025mm. G.S., room temp.: U.T.S. = 107,100 psi - Y.S. = 17,300 psi (0.2% offset), bar supplied - 1/2 inch diam. Bar sample - 0.313 inch diam. - polished, rotating beam (R.R. Moore type), 3500 r.p.m.	95.6	0.2				3.2Si, 0.9Mn, 0.1Fe	10
10b	Hard drawn 39% - R_B = 97 - after 0.110mm. G.S., room temp.: U.T.S. = 95,300 psi - Y.S. = 20,100 psi (0.2% offset). Other specifications same as 10a.	95.6	0.2				3.2Si, 0.9Mn, 0.2Fe	10
10c	Hard drawn 39% - R_B = 96 - after 0.175mm. G.S., room temp.: U.T.S. = 93,500 psi - Y.S. = 18,700 psi (0.2% offset). Other specifications same as 10a.	95.6	0.2				3.2Si, 0.9Mn, 0.1Fe	10
11a	Hard, room temp.: U.T.S. = 97,100 psi - Y.S. = 80,000 psi (0.2% offset) - R_B = 101, bar supplied - 1/2 inch diam. Bar sample - 0.3 inch diam., rotating beam (R.R. Moore type) - 3500 r.p.m.	95.5					3.2Si, 0.2Fe, 1.1Mn	11
11b	1/2 hard, room temp.: U.T.S. = 74,900 psi, R_B = 89. Other specifications same as 11a.	96.1					2.9Si, 0.2Fe, 1.0Mn	11
11c	1/4 hard, room temp.: U.T.S. = 66,600 psi - R_B = 84. Other specifications same as 11a.	96.1					2.9Si, 0.2Fe, 1.0Mn	11
11d	Annealed (soft), room temp.: U.T.S. = 59,500 psi - Y.S. = 14,500 psi (0.2% offset). Other specifications same as 11a.	95.5					3.2Si, 0.2Fe, 1.1Mn	11

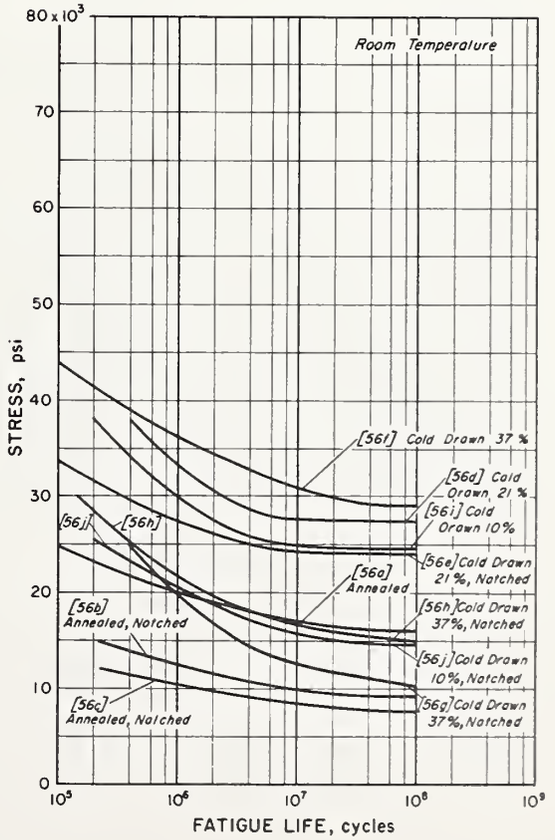


Fatigue Behavior of Cu-Si (Silicon Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
55a	Cold drawn 60% (hard), room temp.: U. T. S. = 73,000 psi - Y. S. = 57,500 psi (0.2% offset). Wire sample - 0.072 inch diam. - made from straightened drawn coil, flexure rotating arc - 3450 r.p.m.	97.1	1.4				1.4Si	55
55b	Drawn 84% (spring temper), room temp.: U. T. S. = 93,500 psi - Y. S. = 75,500 psi (0.2% offset). Other specifications same as 55a.	97.1	1.4				1.4Si	55
55c	Drawn 60% (hard), room temp.: U. T. S. = 111,000 psi - Y. S. = 77,500 psi (0.2% offset). Other specifications same as 55a.	96.2	1.0				2.8Si	55
55d	Drawn 80% (spring temper), room temp.: U. T. S. = 133,500 psi - Y. S. = 89,500 psi (0.2% offset). Other specifications same as 55a.	96.2	1.0				2.8Si	55
126a	60% reduction of area, sheet sample. Machined sample parallel to rolling direction, reciprocating beam - 750 r.p.m. - ratio of length to thickness = 9.287.	95.5					3.6Si, 1.0Mn	126
126b	Specifications same as 126a.	96.0					3.0Si, 1.0Mn	126
126c	Annealed. Other specifications same as 126a.	95.9	0.1			0.1	3.0Si, 0.7Mn, 0.1Fe	126
126d	Specifications same as 126a.	95.9	0.1			0.1	3.0Si, 0.7Mn, 0.1Fe	126
264	Annealed, room temp.: U. T. S. = 104,300 psi - R_B = 93, sheet supplied. Flexure test (Townsend and Greenall machine).	96.4	0.2				3.1Si, 0.2Fe	264
314	Rolled to spring temper, room temp.: U. T. S. = 80,000 psi - R_B = 91, annealed sheet supplied. Samples cut parallel to rolling direction, flexure cantilever - approx. 1500 r.p.m.	95.5					3.6Si, 1.0Mn	314

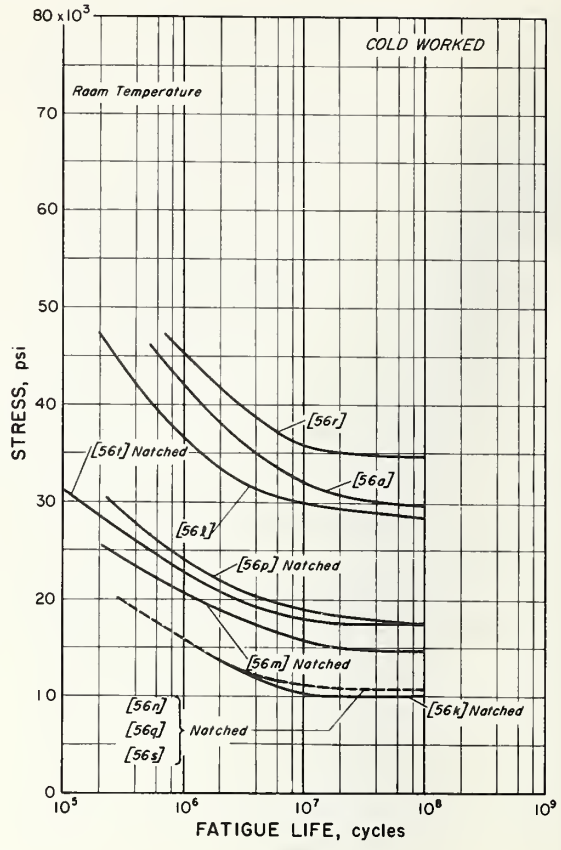


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
56a	Annealed - 0.025mm. G.S., room temp.: U. T. S. = 40,600 psi - Y. S. = 10,800 psi (0.2% offset), bar supplied - 0.56 inch diam. Bar sample - 0.5 inch diam. at ends - reduced to 0.3 inch diam. - polished with 4/0 emery paper, rotating beam (Krouse).	97.2	1.4				1.4Si	56
56b	Notched sample - 0.30 inch diam. at notch - 0.015 inch notch radius (K_T = 3.16) - 60° - 0.35 inch diam. away from notch. Other specifications same as 56a.	97.2	1.4				1.4Si	56
56c	Notched sample - 0.30 inch diam. at notch - 0.001 inch notch radius (K_T = 12.2) - 60° - 0.35 inch diam. away from notch. Other specifications same as 56a.	97.2	1.4				1.4Si	56
56d	Cold drawn 21% - 0.02mm. G.S., room temp.: U. T. S. = 54,000 psi - Y. S. = 48,000 psi (0.2% offset), bar supplied - 0.625 inch diam. Other specifications same as 56a.	97.1	1.4				1.5Si	56
56e	Notched sample - 0.30 inch diam. at notch - 0.0015 inch notch radius (K_T = 10.0) - 60° - 0.35 inch diam. away from notch. Other specifications same as 56d.	97.1	1.4				1.5Si	56
56f	Cold drawn 37% - 0.03mm. G.S., room temp.: U. T. S. = 63,600 psi - Y. S. = 59,000 psi (0.2% offset). Other specifications same as 56a.	97.2	1.2				1.4Si, 0.2Pb	56
56g	Notched sample - 0.30 inch diam. at notch - 0.001 inch notch radius (K_T = 12.2) - 60° - 0.35 inch diam. away from notch. Other specifications same as 56f.	97.2	1.2				1.4Si, 0.2Pb	56
56h	Notched sample - 0.30 inch diam. at notch - 0.015 inch notch radius (K_T = 3.16) - 60° - 0.35 inch diam. away from notch. Other specifications same as 56f.	97.2	1.2				1.4Si, 0.2Pb	56
56i	Cold drawn 10% - 0.02mm. G.S., room temp.: U. T. S. = 62,700 psi - Y. S. = 42,400 psi (0.2% offset), bar supplied - 0.563 inch diam. Other specifications same as 56a.	95.9	1.0				3.0Si	56
56j	Notched sample - 0.30 inch diam. at notch - 0.015 inch notch radius (K_T = 3.16) - 60° - 0.35 inch diam. away from notch. Other specifications same as 56i.	95.9	1.0				3.0Si	56



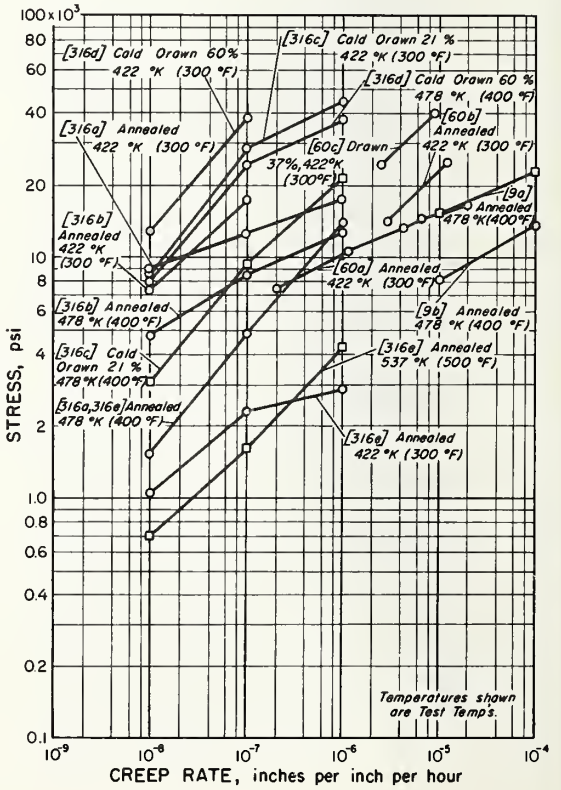
Fatigue Behavior of Cu-Si (Silicon Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
56k	Cold drawn 10% - 0.02mm. G.S., room temp.: U.T.S. = 62,700 psi - Y.S. = 42,400 psi (0.2% offset), bar supplied - 0.563 inch diam. Notched sample - 0.30 inch diam. at notch - 0.001 inch notch radius (K_T = 12.2) - 0.35 inch diam. away from notch - 60°, rotating beam (Krouse).	95.9	1.0				3.0Si	56
56l	Cold drawn 23% - 0.035mm. G.S., room temp.: U.T.S. = 76,600 psi - Y.S. = 56,700 psi (0.2% offset), bar supplied - 0.563 inch diam. Bar sample - 0.5 inch diam. at ends - reduced to 0.3 inch diam. - polished with 4/0 emery paper, rotating beam (Krouse).	95.9	1.0				3.0Si	56
56m	Cold drawn 23% - 0.35mm. G.S., room temp.: U.T.S. = 76,600 psi - Y.S. = 56,700 psi (0.2% offset). Notched sample - 0.015 inch radius (K_T = 3.16). Other specifications same as 56k.	95.9	1.0				3.0Si	56
56n	Notch radius - 0.001 inch (K_T = 12.2). Other specifications same as 56m.	95.9	1.0				3.0Si	56
56o	Cold drawn 33% - 0.025mm. G.S., room temp.: U.T.S. = 93,200 psi - Y.S. = 67,000 psi (0.2% offset). Other specifications same as 56l.	95.9	1.0				3.0Si	56
56p	Notched sample - 0.30 inch diam. at notch - 0.015 inch notch radius (K_T = 3.16) - 60° - 0.35 inch diam. away from notch. Other specifications same as 56o.	95.9	1.0				3.0Si	56
56q	Notch radius = 0.001 inch (K_T = 12.2). Other specifications same as 56p.	95.9	1.0				3.0Si	56
56r	Cold drawn 44% - 0.04mm. G.S., room temp.: U.T.S. = 102,500 psi - Y.S. = 80,000 psi (0.2% offset). Other specifications same as 56l.	95.9	1.0				3.0Si	56
56s	Notched sample - 0.30 inch diam. at notch - 0.015 inch notch radius (K_T = 3.16) - 60° - 0.35 inch diam. away from notch. Other specifications same as 56r.	95.9	1.0				3.0Si	56
56t	Notch radius = 0.001 inch (K_T = 12.2). Other specifications same as 56s.	95.9	1.0				3.0Si	56



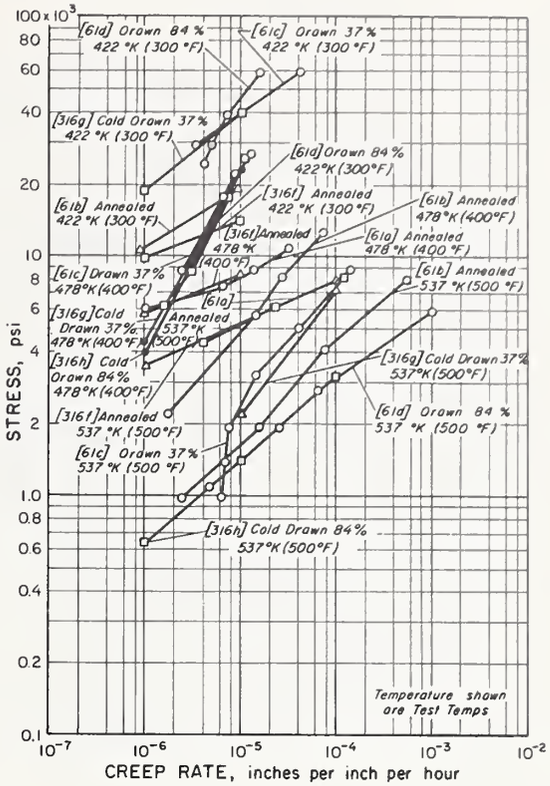
Creep Behavior of Cu-Si (Silicon Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
9a	Annealed.	95.6	0.2				2.8Si, 1.2Mn, 0.2Fe	9
9b	Annealed 842°F - R_B = 75, 3/4 inch cold drawn bar supplied.	95.6	0.2				2.8Si, 1.2Mn, 0.2Fe	9
60a	Annealed - 0.1mm. G.S. Constant load tests.	96.3	0.8				2.8Si, 0.1Fe	60
60b	Annealed - 0.008mm. G.S. Constant load tests.	96.3	0.8				2.8Si, 0.1Fe	60
60c	Drawn 37%.	96.3	0.8				2.8Si, 0.1Fe	60
316a	Annealed - 0.025mm. G.S., wrought bar supplied. Bar sample - 0.125 inch diam.	97.4	1.0				1.6Si	316
316b	Annealed - 0.060mm. G.S., wrought bar supplied. Bar sample - 0.125 inch diam.	97.4	1.0				1.6Si	316
316c	Cold drawn 21%, wrought bar supplied. Bar sample - 0.125 inch diam.	97.4	1.0				1.6Si	316
316d	Cold drawn 60%, wrought bar supplied. Bar sample - 0.125 inch diam.	97.4	1.0				1.6Si	316
316e	Annealed - 0.008mm. G.S., wrought bar supplied. Bar sample - 0.125 inch diam.	96.3	0.8				2.8Si, 0.1Fe	316



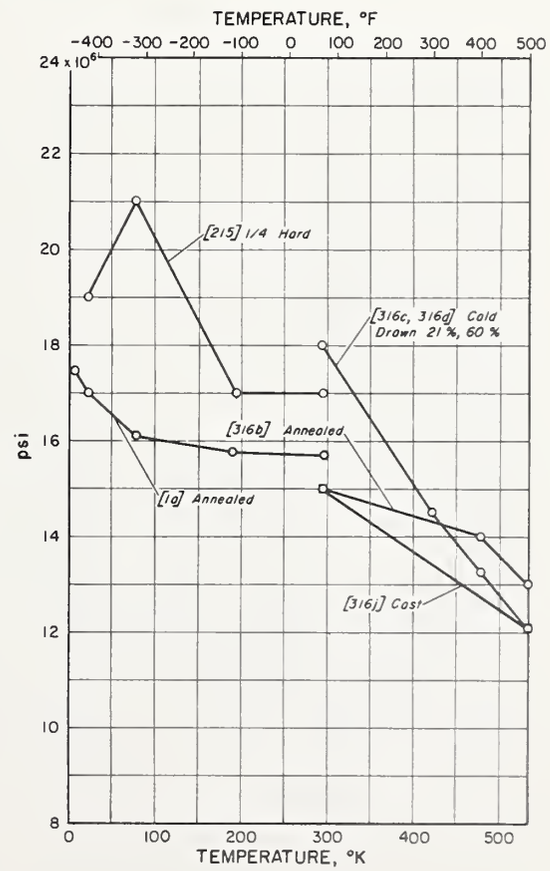
Creep Behavior of Cu-Si (Silicon Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
61a	Annealed - 0.1mm. G.S.	96.3	0.8				2.8Si, 0.1Fe	61
61b	Annealed - 0.008mm. G.S.	96.3	0.8				2.8Si, 0.1Fe	61
61c	Drawn 37%.	96.3	0.8				2.8Si, 0.1Fe	61
61d	Drawn 84%. Final microstructures at 500°F recrystallized.	96.3	0.8				2.8Si, 0.1Fe	61
316f	Annealed - 0.10mm. G.S., wrought bar supplied. Bar sample - 0.125 inch diam.	96.3	0.8				2.8Si, 0.1Fe	316
316g	Cold drawn 37%, wrought bar supplied. Bar sample - 0.125 inch diam.	96.3	0.8				2.8Si, 0.1Fe	316
316h	Cold drawn 84%, wrought bar supplied. Bar sample - 0.125 inch diam.	96.3	0.8				2.8Si, 0.1Fe	316



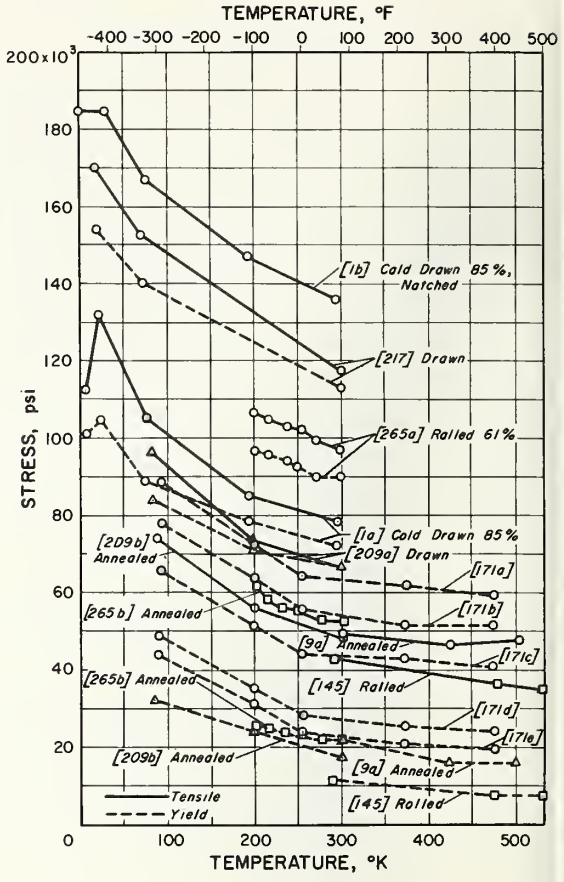
Modulus of Elasticity of Cu-Si (Silicon Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed (soft) - 0.25mm. G.S. - R_B = 54, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch per minute, clamp-on strain gage extensometer - 1 inch G.L.	Bal					2.9Si, 0.9Mn 0.1Fe	1
215	1/4 hard - R_B = 78. Samples cut longitudinally from sheet, crosshead speed = 0.2 inches/minute.	95.8					3.1Si, 0.9Mn	215
316b	Annealed - 0.060mm. G.S., wrought bar supplied. Bar sample - 0.125 inch diam.	97.4	1.0				1.6Si	316
316c	Cold drawn 21%, wrought bar supplied. Bar sample - 0.125 inch diam.	97.4	1.0				1.6Si	316
316d	Cold drawn 60%, wrought bar supplied. Bar sample - 0.125 inch diam.	97.4	1.0				1.6Si	316
316j	Cast (double keel blocks) - R_B = 52. Machined sample.	94.6					4.1Si, 0.9Mn	316

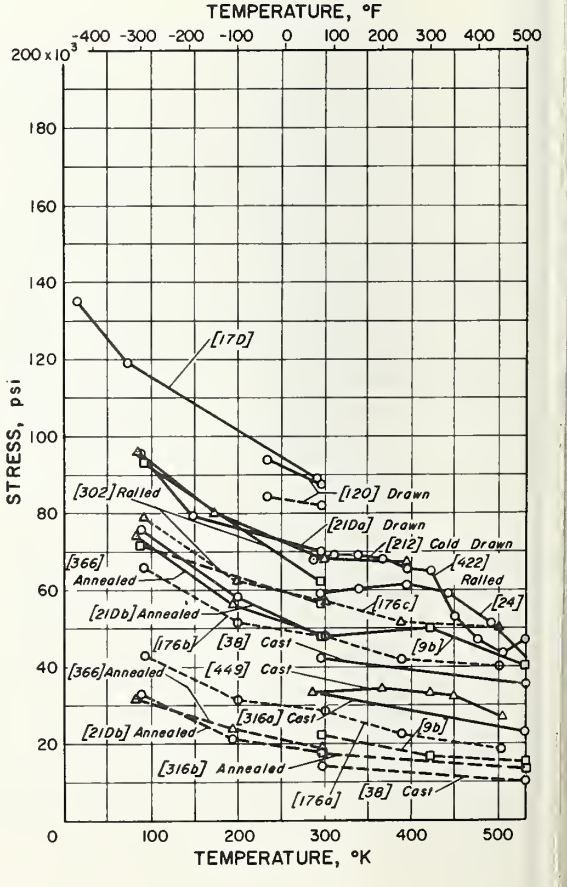


Tensile and Yield Strength of Cu-Sn (Phosphor Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Cold drawn 85% (spring) - 0.101mm. G.S. - R_B = 94, grade A, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, Y.S. - 0.2% offset.	94.9	0.1	4.8			0.2P	1
1b	Notched sample: 0.25 inch diam. at roots - 0.005 ± 0.0005 inch radius (K_T = 5.0). Other specifications same as 1a.	94.9	0.1	4.8			0.2P	1
9a	Annealed 1250°F - after hot rolling, grade A, bar supplied - 3/4 inch diam. Y.S. - 0.2% offset.	95.6		3.8			0.2P, 0.2Fe	9
145	Rolled, grade E, bar supplied - 1 inch diam. Y.S. - 0.2% offset.	97.5		2.4				145
171a	0.0005mm. G.S., grade C.	92.7		7.3				171
171b	0.0008mm. G.S., grade C.	92.7		7.3				171
171c	0.0017mm. G.S., grade C.	92.7		7.3				171
171d	0.0089mm. G.S., grade C.	92.7		7.3				171
171e	0.024mm. G.S., grade C.	92.7		7.3				171
209a	Cold drawn, grade A, bar supplied - 0.873 inch diam. Y.S. - 0.2% offset.	95.2		4.6			0.1P	209
209b	Annealed 1200°F - 1/2 hr. - furnace cooled, grade A, bar supplied - 0.873 inch diam. Y.S. - 0.2% offset.	95.2		4.6				209
217	Full hard - R_B= 100, grade C, bar supplied - 3/4 inch diam. Bar sample - 0.25 inch diam., strain rate to Y.S. = 0.0005 inch/inch/minute, strain rate to U.T.S. = 0.02 inch/inch/minute, Y.S. - 0.2% offset.	90.3		9.2				217
265a	Rolled 61% to spring temper, grade A, sheet sample - 1/16 inch thick X 1/2 inch wide.	94.8	0.1	4.9			0.1P	265
265b	Annealed, grade A. Sheet sample - 1/16 inch thick X 1/2 inch wide.	94.8	0.2	4.6			0.2P	265

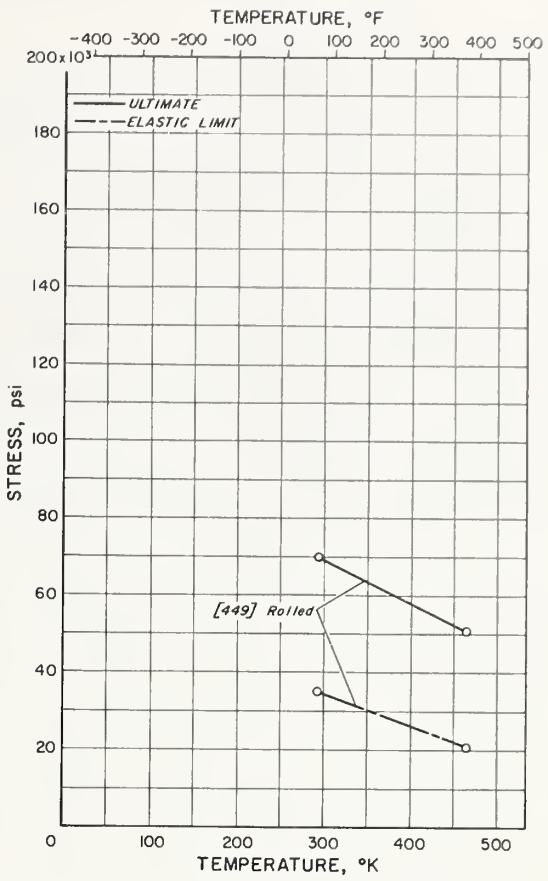


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
9b	Grade A. Wrought bar supplied - 5/8 inch diam. Y.S. - 0.2% offset.	94.3		5.5			0.2P	9
24	Grade D. Wrought.	89.5		10.5				24
38	Cast, grade D. Y.S. - 0.2% offset.	88.0		12.0				38
120	Hard drawn, grade A, bar supplied - 1/2 inch diam. Bar sample - 0.375 inch diam., Y.S. - 0.2% offset.	95.6		4.0			0.4P	120
170	Grade A. Bar sample - 0.118 inch diam.	93.1		6.5			0.4P	170
176a	0.024mm. G.S., grade C.	92.2		7.8				176
176b	0.0017mm. G.S., grade C.	92.2		7.8				176
176c	0.0008mm. G.S., grade C.	92.2		7.8				176
210a	Cold drawn, grade A, bar supplied - 0.118 inch diam.	95.7		3.9			0.3P	210
210b	Annealed 1200°F - 1/2 hr., grade A, bar supplied - 0.118 inch diam. Y.S. - 0.2% offset.	95.7		3.9			0.3P	210
212	Cold drawn, grade A, bar supplied - 3/4 inch diam.	95.8		3.9			0.3P	212
302	Rolled, grade A. Bar sample, Y.S. - 0.2% offset.	95.7		4.0			0.3P	302
316a	Cast - R_B = 30, grade D, bar supplied - 1 inch square.	89.8		9.5			0.1Pb	316
316b	Annealed - 0.050mm. G.S. - grade A. Wire sample - 0.125 inch diam. Y.S. - 0.2% offset.	94.2		5.6			0.2P	316
366	Annealed 1200°F, grade A, bar supplied - 3/4 inch diam. Y.S. - 0.1% offset.	95.8		3.9			0.3P	366
422	Rolled, grade C. Bar sample - 1 inch diam.	92.5		7			0.5P	422
449	Cast, grade D.	89.5		10.2			0.3Fe	449



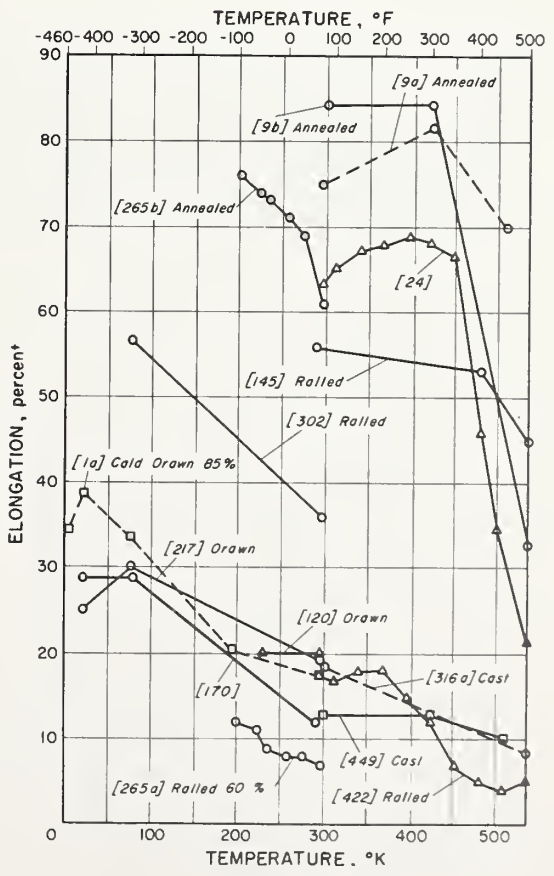
Shear Strength of Cu-Sn (Phosphor Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
449	Rolled, grade A. Bar sample - 0.855 inch diam., tested in torsion.	95.5		3.9			0.3P, 0.2Fe	449



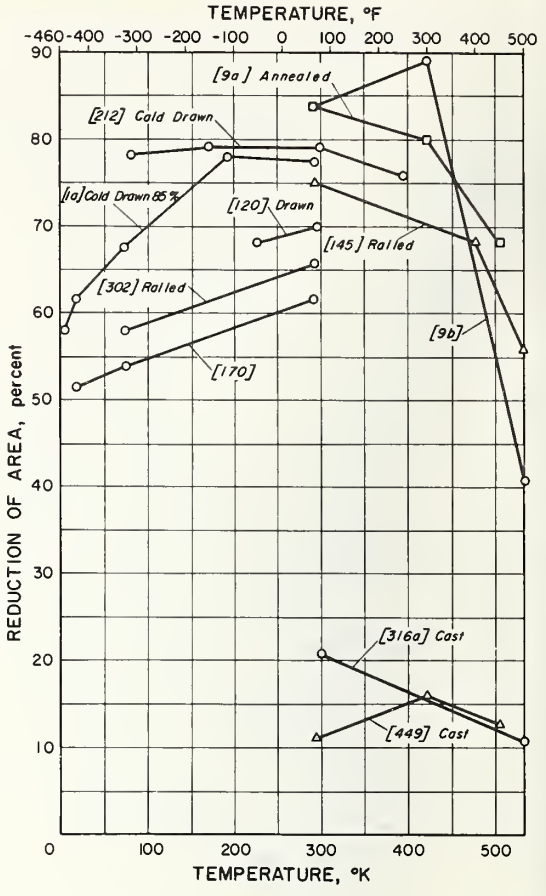
Tensile Elongation of Cu-Sn (Phosphor Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
1a	Cold drawn 85% (spring) - 0.101mm. G.S. - R_B = 94, grade A, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, 1 inch G.L.	94.9	0.1	4.8			0.2P	1
9a	Annealed 1250°F - after hot rolling, grade A, bar supplied - 3/4 inch diam. 2 inch G.L.	95.6		3.8			0.2P, 0.2Fe	9
9b	Wrought, grade A, bar supplied - 5/8 inch diam. 2 inch G.L.	94.3		5.5			0.2P	9
24	Wrought, grade D. 2 inch G.L.	89.5		10.5				24
120	Drawn, grade A, bar supplied - 1/2 inch diam. Bar sample - 0.375 inch diam., 2 inch G.L.	95.6		4.0			0.4P	120
145	Rolled, grade E, bar supplied - 1 inch diam. 2 inch G.L.	97.5		2.4				145
170	Grade A. Bar sample - 0.118 inch diam., 1.88 inch G.L.	93.1		6.5			0.4P	170
217	Drawn, grade C, bar supplied - 3/4 inch diam. Bar sample - 0.25 inch diam., strain rate = 0.02 inch/inch/minute, 1 inch G.L.	90.3		8.2				217
265a	Rolled 60.5% (spring), grade A. Sheet sample - 1/16 inch thick X 1/2 inch wide, 2 inch G.L.	94.8	0.1	4.9			0.1P	265
265b	Annealed, grade A. Sheet sample - 1/16 inch thick X 1/2 inch wide, 2 inch G.L.	94.9	0.2	4.6			0.2P	265
302	Rolled, grade A. Bar sample, 2 inch G.L.	95.7		4.0			0.3P	302
316a	Cast - R_B = 30, grade D, bar supplied - 1 inch square, 2 inch G.L.	89.8		9.5			0.1Pb	316
422	Rolled, grade C. Bar sample - 1 inch diam.	92.5		7			0.5P	422
449	Cast, grade D.	89.5		10.2			0.3Fe	449



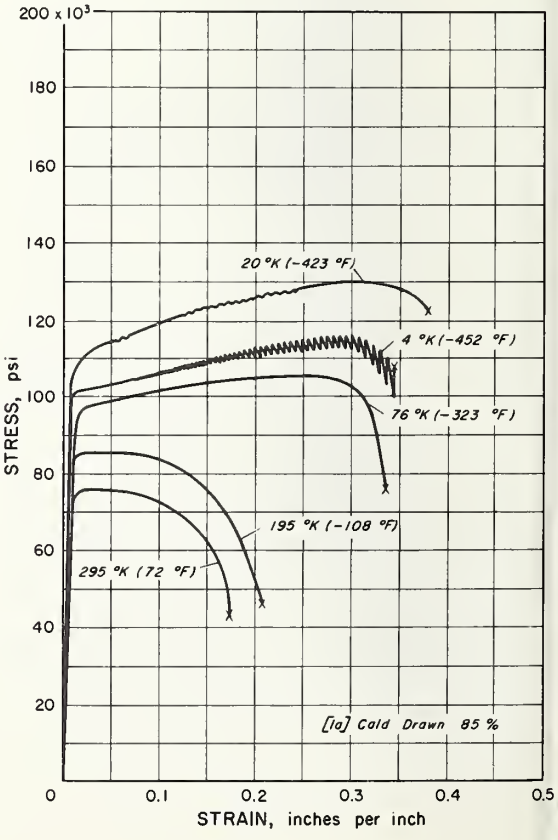
Tensile Reduction of Area of Cu-Sn (Phosphor Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Cold drawn 85% (spring) - 0.101mm. G.S. - R_B = 94, grade A, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long × 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute.	94.9	0.1	4.8			0.2P	1
9a	Annealed 1250°F - after hot rolling, grade A, bar supplied - 3/4 inch diam.	95.6		3.8			0.2P, 0.2Fe	9
9b	Grade A. Wrought bar supplied - 5/8 inch diam.	94.3		5.5			0.2P	9
120	Hard drawn, grade A, bar supplied - 1/2 inch diam. Bar sample 0.375 inch diam.	95.6		4.0			0.4P	120
145	Rolled, grade E, bar supplied - 1 inch diam.	97.5		2.4				145
170	Grade A. Bar sample - 0.118 inch diam.	93.1		6.5			0.4P	170
212	Cold drawn, grade A, bar supplied - 0.75 inch diam.	95.8		3.9			0.3P	212
302	Rolled, grade A. Bar sample.	95.7		4.0			0.3P	302
316a	Cast - R_B = 30, grade D, bar supplied - 1 inch square.	89.8		9.5			0.1Pb	316
449	Cast, grade D.	89.5		10.2			0.3Fe	449



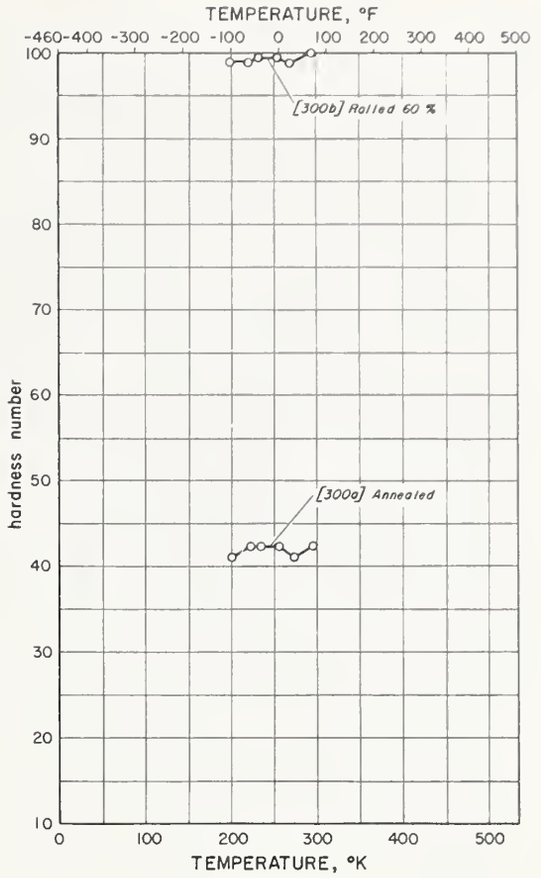
Tensile Stress-Strain Curves of Cu-Sn (Phosphor Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Cold drawn 85% (spring), 0.101mm. G.S. - R_B = 94, grade A, bar supplied - 3/4 inch diam. Bar sample - reduced section - 1.5 inches long × 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer - 1 inch G.L.	94.9	0.1	4.8			0.2P	1



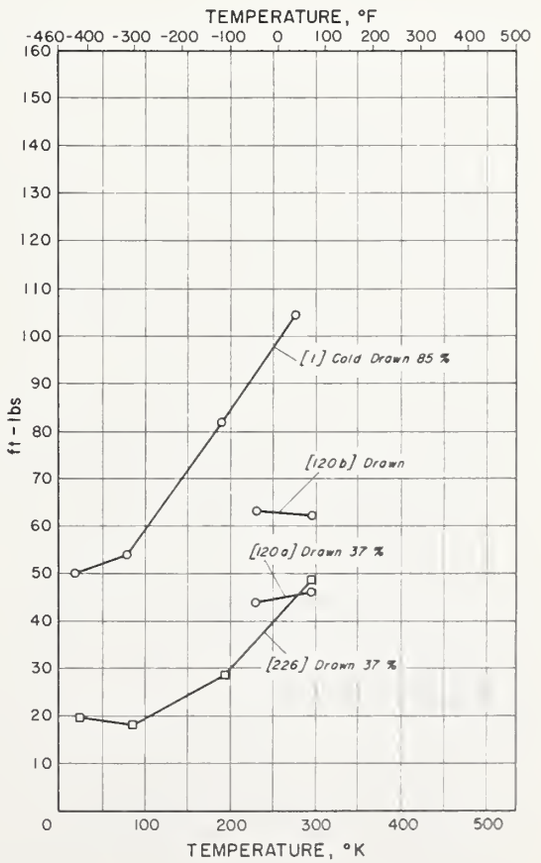
Hardness of Cu-Sn (Phosphor Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
300a	Annealed, grade A. Sample 1/16 inch thick, Rockwell B.	94.9	0.2	4.6			0.2P	300
300b	Spring temper. Sample 1/16 inch thick, Rockwell B.	94.8	0.1	4.9			0.1P	300



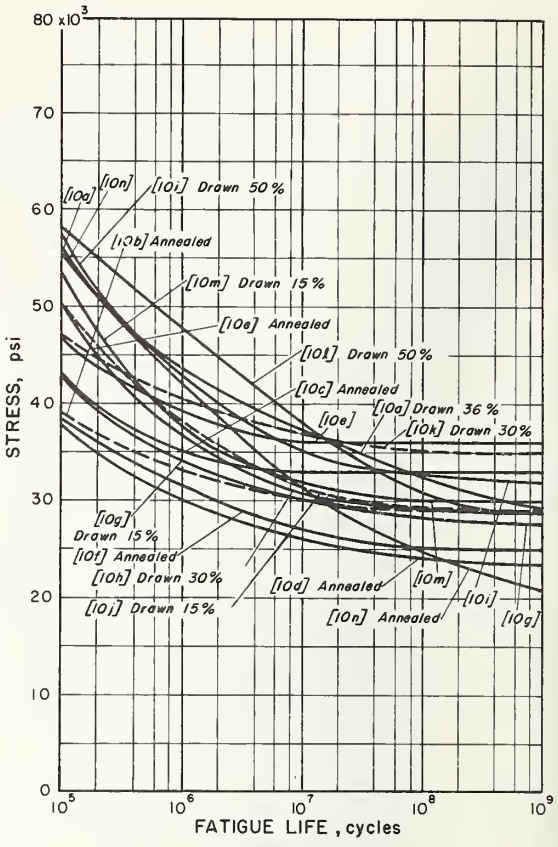
Impact Energy of Cu-Sn (Phosphor Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1	Cold drawn 85% (spring) - 0.101mm. G.S. - R_B = 94, grade A, bar supplied - 3/4 inch diam. Charpy V-notch, 95% fracture - all temps, paper container glued to samples used for -423°F tests.	94.9	0.1	4.8			0.2P	
120a	Drawn 37%, grade A, bar supplied - 1/2 inch diam. Izod.	95.6		4.0			0.4P	120
120b	Drawn, grade A. Izod.	94.6	0.3	5.0			0.1Pb	120
226	Reduced 37% - R_B = 97.5, grade D. Charpy V-notch.	Bal		10				226

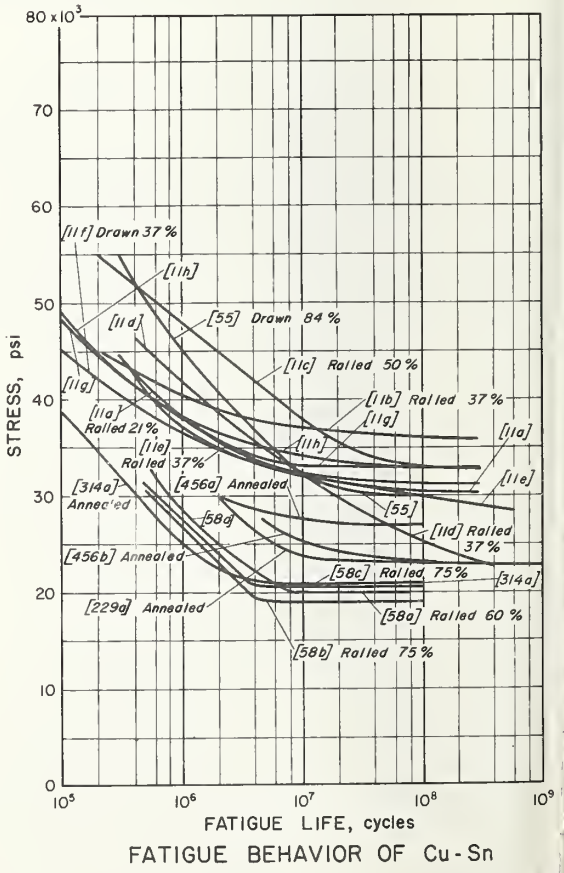


Fatigue Behavior of Cu-Sn (Phosphor Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
10a	Drawn 36% -0.018mm. G.S., room temp.: U.T.S. = 80,200 psi - Y.S. = 78,400 psi (0.2% offset) - R_B = 85, grade A, bar supplied - 1/2 inch diam. Bar sample - 0.3 inch reduced diam., rotating beam - 3500r.p.m., R = -1.	95.2		3.7			0.8Fe, 0.2Mn	10
10b	Annealed 1022°F -0.025mm. G.S., room temp.: U.T.S. = 50,600 psi - Y.S. = 20,200 psi (0.2% offset) - R_B = 34. Data spread = ± 3.5%. Other specifications same as 10a.	95.3		4.3			0.4P	10
10c	Annealed 1022°F -0.020mm. G.S., room temp.: U.T.S. = 59,200 psi - Y.S. = 24,500 psi (0.2% offset) - R_B = 50. Data spread = ± 3%. Other specifications same as 10a.	91.8		8.1			0.1P	10
10d	Annealed 1157°F -0.070mm. G.S., room temp.: U.T.S. = 55,500 psi - Y.S. = 20,000 psi (0.2% offset) - R_B = 41. Data spread = ± 6.5%. Other specifications same as 10a.	91.8		8.1			0.1P	10
10e	Annealed 1022°F -0.016mm. G.S., room temp.: U.T.S. = 68,000 psi - Y.S. = 28,400 psi (0.2% offset) - R_B = 60. Other specifications same as 10c.	89.9	0.1	9.8			0.1P, 0.1Fe	10
10f	Annealed 1202°F -0.065 to 0.070mm. G.S., room temp.: U.T.S. = 62,200 psi - Y.S. = 21,200 psi (0.2% offset) - R_B = 49. Data spread = ±4%. Other specifications same as 10a.	89.9	0.1	9.8			0.1P, 0.1Fe	10
10g	Drawn 15.2% - 0.070mm. G.S., room temp.: U.T.S. = 56,700 psi - Y.S. = 49,700 psi (0.2% offset) - R_B = 72. Data spread = ± 7.5%. Other specifications same as 10a.	95.3		4.3			0.4P	10
10h	Drawn 30.1% - 0.090mm. G.S., room temp.: U.T.S. = 69,800 psi - Y.S. = 61,700 psi (0.2% offset) - R_B = 92. Data spread = ± 7%. Other specifications same as 10a.	95.3		4.3			0.4P	10
10i	Drawn 50.1% - 0.065mm. G.S., room temp.: U.T.S. = 96,600 psi - Y.S. = 84,000 psi (0.2% offset) - R_B = 92. Data spread = ± 9.5%. Other specifications same as 10a.	95.3		4.3			0.4P	10
10j	Drawn 15.2% - 0.1mm. G.S., room temp.: U.T.S. = 66,000 psi - Y.S. = 49,100 psi (0.2% offset) - R_B = 80. Data spread = ± 7%. Other specifications same as 10a.	91.8		8.1			0.1P	10
10k	Drawn 30.1% - 0.090 to 0.1mm. G.S., room temp.: U.T.S. = 81,000 psi - Y.S. = 64,500 psi (0.2% offset) - R_B = 97. Data spread = ± 9%. Other specifications same as 10a.	91.8		8.1			0.1P	10
10ℓ	Drawn 50.1% - 0.110mm. G.S., room temp.: U.T.S. = 110,300 psi - Y.S. = 93,100 psi (0.2% offset) - R_B = 98. Data spread = ± 17%. Other specifications same as 10a.	91.8		8.1			0.1P	10
10m	Drawn 15.2% - 0.075mm. G.S., room temp.: U.T.S. = 76,600 psi - Y.S. = 50,300 psi (0.2% offset) - R_B = 92. Data spread = ± 3.5%. Other specifications same as 10a.	89.9	0.1	9.8			0.1P, 0.1Fe	10
10n	Drawn 30.1% - 0.090mm. G.S., room temp.: U.T.S. = 92,100 psi - Y.S. = 70,400 psi (0.2% offset) - R_B = 97. Other specifications same as 10b.	89.9	0.1	9.8			0.1P, 0.1Fe	10



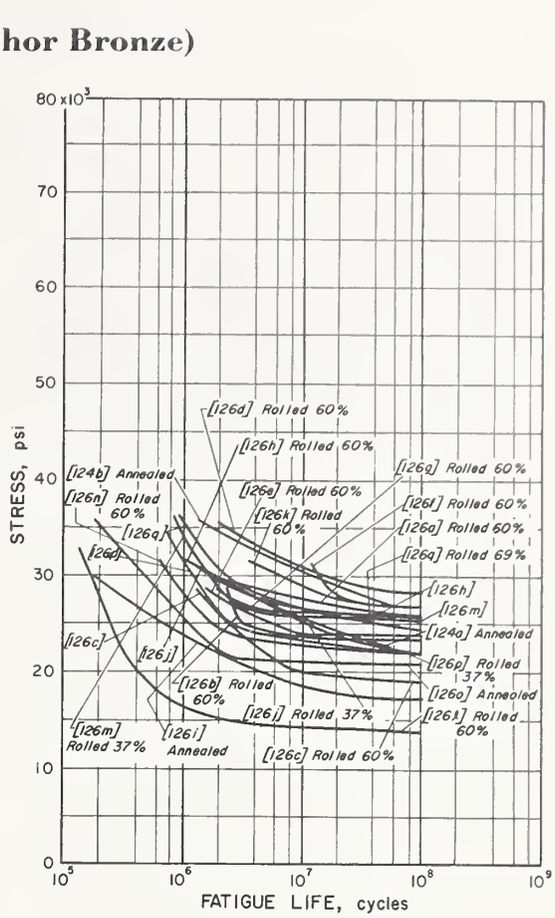
CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
11a	1/2 hard -0.10mm. G.S., room temp.: Y.S. = 49,100 psi (0.2% offset), grade C. Bar sample - 0.30 inch reduced diam. polished, rotating beam (R.R. Moore type).	91.8		8.1				11
11b	Full hard -0.10mm. G.S., room temp.: Y.S. = 64,500 psi (0.2% offset). Other specifications same as 11a.	91.8		8.1				11
11c	Extra hard -0.10mm. G.S., room temp.: Y.S. = 93,100 psi (0.2% offset). Other specifications same as 11a.	91.8		8.1				11
11d	Full hard -0.09mm. G.S., room temp.: Y.S. = 70,400 psi (0.2% offset), grade D. Other specifications same as 11a.	89.8	0.2	9.8			0.1P	11
11e	Full hard -0.09mm. G.S., room temp.: Y.S. = 61,600 psi (0.2% offset), grade A. Other specifications same as 11a.	95.2		4.3			0.4P	11
11f	Drawn 36.6% -0.015mm. G.S., room temp.: U.T.S. = 59,200 psi - Y.S. = 54,800 psi (0.2% offset), grade E, bar supplied - 0.398 inch diam. Bar sample -0.25 inch diam., rotating beam - 1600r.p.m., R = -1, data spread = ± 5%.	98.6		1.2				11
11g	Drawn 36.6%, room temp.: U.T.S. = 62,400 psi - Y.S. = 57,300 psi (0.2% offset). Other specifications same as 11f.	98.3		1.6				11
11h	Rotating beam - 3500r.p.m. Other specifications same as 11f.	98.3		1.6				11
55	Drawn 84%, room temp.: U.T.S. = 121,000 psi - Y.S. = 101,500 psi, grade A. Wire sample -0.072 inch diam., rotating arc - 3450r.p.m., R = -1.	95.4		4.4			0.3P	55
58a	Reduced 60% -0.12mm. G.S., room temp.: U.T.S. = 95,000 psi - Y.S. = 87,500 psi (0.2% offset), grade A. Sheet sample - 0.032 inch thick, tested in rolling direction, flexure cantilever - 900c.p.m., R = -1.	95.4		4.0			0.2P	58
58b	Rolled 60%, room temp.: U.T.S. = 68,900 psi - Y.S. = 64,500 psi (0.2% offset). Other specifications same as 58a.	98.5	0.1	1.4				58
58c	Rolled 75%, room temp.: U.T.S. = 73,600 psi - Y.S. = 67,500 psi (0.2% offset). Other specifications same as 58a.	98.5	0.1	1.4				58
229a	Annealed - after drawing, room temp.: U.T.S. = 45,700 psi, grade A, bar supplied - 3/4 inch diam. Rotating beam (Farmer) - 1500r.p.m., R = -1, data spread = ± 14%.	94.9		4.9				229
314a	Annealed, room temp.: U.T.S. = 59,700 psi - R_B = 11, grade C. Sheet sample -0.020 inch thick - cut parallel to rolling direction, rotating cantilever - 1500r.p.m., R = -1.	91.8		8.1				314
456a	Annealed 400°F - 3 hrs. - oil cooled, room temp.: U.T.S. = 63,000 psi - Y.S. = 48,000 psi - Brinell hardness = 107, grade A. Bar sample - 0.46 inch ave. reduced diam., rotating cantilever - 1200 to 1450r.p.m., R = -1. Tested in air.	94.6		5.4			0.1P, 0.1Fe	456
456b	Tested in fresh water, 1450r.p.m. Other specifications same as 456a.	94.6		5.4			0.1P, 0.1Fe	456



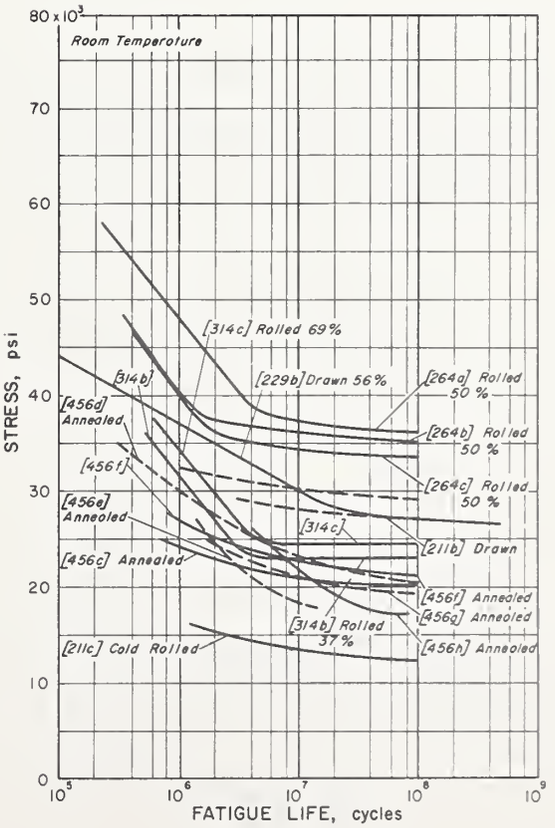
FATIGUE BEHAVIOR OF Cu-Sn

Fatigue Behavior of Cu-Sn (Phosphor Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
124a	Annealed 527°F - 1/2 hr. - air cooled, room temp.: U.T.S. = 61,800 psi - Y.S. = 57,100 psi (0.1% offset) - Brinell hardness = 138, grade A. Bar sample - 0.275 inch diam., rotating beam - 2200 r.p.m., R = -1, tested in air.	Bal		3.5 5.0			0.1 - 0.4P	124
124b	Tested in distilled water of 3% salt. Other specifications same as 124a.							124
126a	Reduced 60.5%, room temp.: U.T.S. = 115,300 psi, grade C, Sheet sample - 0.020 inch thick, tested in rolling direction, flexure cantilever - 750 c.p.m., R = -1.	91.0	0.2	8.0			0.2P	126
126b	Cleaned and plated with 20 mgm./inch^2 nickel and chromium. Other specifications same as 126a	91.0	0.2	8.0				126
126c	Cleaned and plated with 20 mgm./inch^2 chromium. Other specifications same as 126a.	91.0	0.2	8.0				126
126d	"Microscopic polish." Other specifications same as 126a.	91.0	0.2	8.0				126
126e	Cleaned and plated with 10 mgm/inch^2 nickel. Other specifications same as 126a.	91.0	0.2	8.0			0.2P	126
126f	Sand blasted and plated with 10 mgm/inch^2 chromium. Other specifications same as 126a.	91.0	0.2	8.0				126
126g	Polished - sand blasted and plated with 10 mgm/inch^2 chromium. Other specifications same as 126a.	91.0	0.2	8.0				126
126h	Polished - bubbed and plated with 10 mgm/inch^2 chromium. Other specifications same as 126a.	91.0	0.2	8.0				126
126i	Annealed, room temp.: U.T.S. = 51,800 psi. Other specifications same as 126a.	92.0	0.2	7.7				126
126j	Reduced 37.1%, room temp.: U.T.S. = 88,000 psi. Other specifications same as 126a.	92.0	0.2	7.7				126
126k	Reduced 60.5%, room temp.: U.T.S. = 112,900 psi. Other specifications same as 126a.	92.0	0.2	7.7				126
126ℓ	Annealed, grade A. Other specifications same as 126a.	95.8	0.1	3.9				126
126m	Reduced 37.1%, room temp.: U.T.S. = 78,800 psi. Other specifications same as 126ℓ.	95.8	0.1	3.9				126
126n	Reduced 60.5%, room temp.: U.T.S. = 90,200 psi. Other specifications same as 126ℓ.	95.8	0.1	3.9				126
126o	Annealed, room temp.: U.T.S. = 59,700 psi. Other specifications same as 126a.	91.8		8.1				126
126p	Reduced 37.1%, room temp.: U.T.S. = 95,500 psi. Other specifications same as 126a.	91.8		8.1				126
126q	Reduced 68.7%, room temp.: U.T.S. = 124,800 psi. Other specifications same as 126a.	91.8		8.1				126

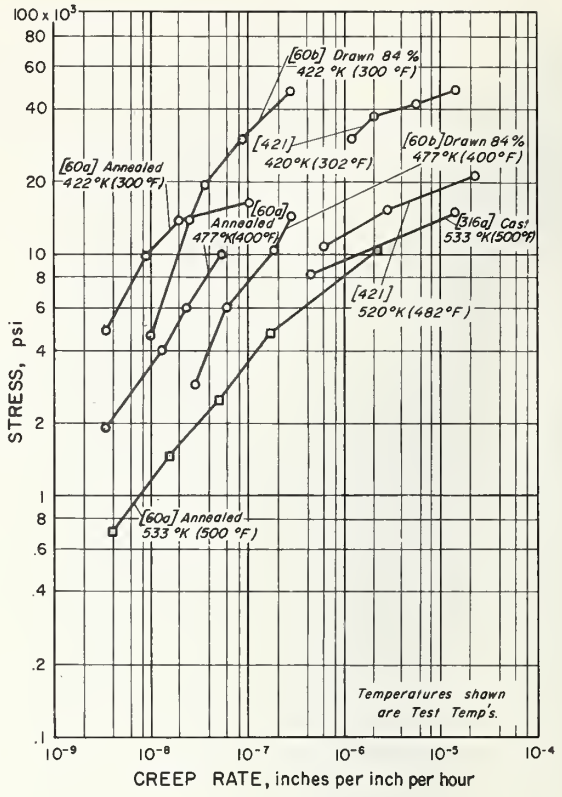


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
211b	Cold drawn, room temp.: U.T.S. = 62,900 psi. Other specifications same as 211a.	94.9		5.0				211
211c	Cold rolled, room temp.: U.T.S. = 58,600 psi, grade A. Alternating torsion - 2140 c.p.m., R = -1, data spread = ±7%.	95.2		4.7			0.1P	211
229b	Drawn 56%, room temp.: U.T.S. = 85,100 psi, grade A, bar supplied - 3/4 inch diam. Rotating beam (Farmer) - 1500 r.p.m., R = -1, data spread = ± 14%.	94.9		4.9				229
264a	Reduced 50%, room temp.: U.T.S. = 97,900 psi, grade A. Sheet sample - 0.025 inch thick - polished with 00 emery, tested in rolling direction, flexure cantilever - 900 c.p.m., R = -1	95.1		4.7				264
264b	Room temp.: U.T.S. = 98,700 psi. Other specifications same as 264a.	95.2		4.7			0.1P	264
264c	Room temp.: U.T.S. = 104,200 psi. Other specifications same as 264a.	92.0	0.5	7.4				264
314b	Rolled 37.1%, room temp.: U.T.S. = 95,500 psi - R_B = 71, grade C. Sheet sample - 0.019 inch thick - cut parallel to rolling direction, rotating cantilever - 1500 r.p.m., R = -1.	91.8		8.1				314
314c	Rolled 68.7%, room temp.: U.T.S. = 124,800 psi - R_B = 84. Other specifications same as 314b.	91.8		8.1				314
456c	Annealed 1200°F - 1 hr. - air cooled, room temp.: U.T.S. = 48,000 psi - Y.S. - 16,750 psi - Brinell hardness = 56, rotating cantilever - 1200 to 1450 r.p.m., R = -1. Tested in air.	94.6		5.4			0.1P, 0.1Fe	456
456d	Annealed 400°F - 4 hrs. - oil cooled, room temp.: 81,000 psi - Y.S. = 43,300 psi - Brinell hardness = 121, grade C. Other specifications same as 456c.	91.7		8.2			0.1P, 0.1Fe	456
456e	Tested in fresh water, 1450 r.p.m. Other specifications same as 456d.	91.7		8.2			0.1P, 0.1Fe	456
456f	Annealed 1200°F - 1 hr. - furnace cooled, room temp.: U.T.S. = 55,400 psi - Y.S. = 19,800 psi - Brinell hardness = 55, grade C. Other specifications same as 456c.	91.7		8.2			0.1P, 0.1Fe	456
456g	Tested in salt water, 1450 r.p.m. Other specifications same as 456f.	91.7		8.2			0.1P, 0.1Fe	456
456h	Annealed 400°F - 3 hrs. - furnace cooled, room temp.: U.T.S. = 86,700 psi - Y.S. = 46,500 psi - Brinell hardness = 121, grade D. Other specifications same as 456c.	89.4		10.5			0.1P, 0.1Fe	456



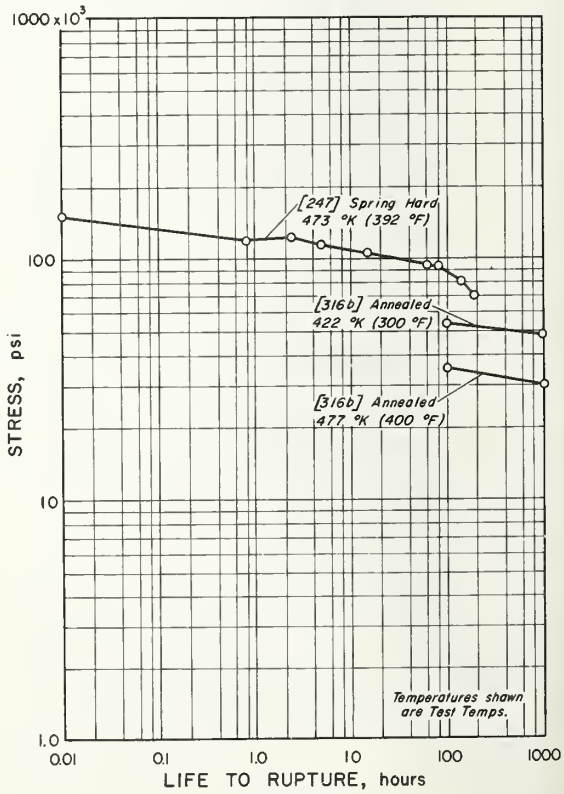
Creep Behavior of Cu-Sn (Phosphor Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
60a	Annealed - 0.050mm. G.S., room temp.: U.T.S. = 52,000 psi - Y.S. = 20,000 psi (0.5% strain), grade A. Bar sample 1/8 inch diam., 300°F and 400°F: 2nd stage; 500°F: 3rd stage, 10 inch G.L.	94.1		5.6			0.2P	60
60b	Drawn 84%, room temp.: U.T.S. = 144,000 psi - Y.S. = 77,500 psi (0.5% strain), grade A. Bar sample - 1/8 inch diam., 2nd stage, 10 inch G.L.	94.1		5.6			0.2P	60
316a	Cast - R_B = 30, grade D, bar supplied - 1 inch square. 3rd stage, rupture at 15,000 psi.	89.8		9.5			0.1Pb	316
421	Room temp.: U.T.S. = 48,800 psi - Y.S., grade A, rolled bar supplied - 5/8 inch diam. Bar sample - approx. 0.25 inch diam., temp. accuracy = ± 2°C, extension measured to 0.0001 inch, 2 inch G.L., at 302°F the creep curves were stepped - recorded rate is that which occurred between steps.	94.3		5.5			0.2P	421



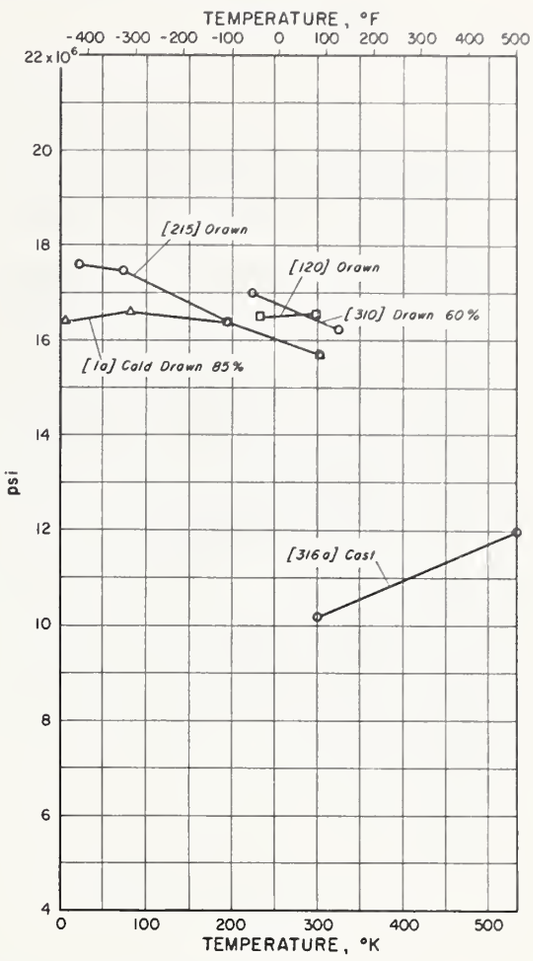
Stress-Rupture Behavior of Cu-Sn (Phosphor Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
247	Spring hard, grade A. Wire sample - 0.040 inch diam.	94.99		5			0.01P	247
316b	Annealed - 0.050mm. G.S, grade A, 1/8 inch diam. Drawn bar supplied.	94.1		5.6			0.2P	316



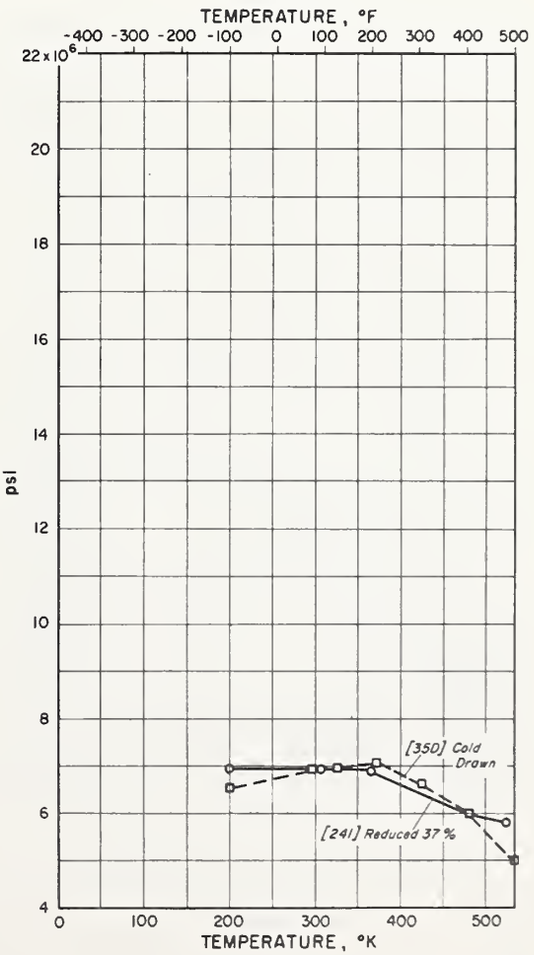
Modulus of Elasticity of Cu-Sn (Phosphor Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Cold drawn 85% (spring) - 0.101mm. G.S. - R_B = 94, grade A, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer, data spread = ± 5%, 1 inch G.L.	94.9	0.1	4.8			0.2P	1
120	Hard drawn, grade A, bar supplied - 1/2 inch diam. Bar sample - 0.375 inch diam.	95.6		4.0			0.4P	120
215	Drawn, grade C, bar supplied - 3/4 inch diam. Bar sample - 0.25 inch diam.	90.3		8.2				215
310	Drawn to spring temper, grade A.	94.6		5.1			0.3P	310
316a	Cast - R_B = 30, grade D, bar supplied - 1 inch square.	89.8		9.5			0.1Pb	316



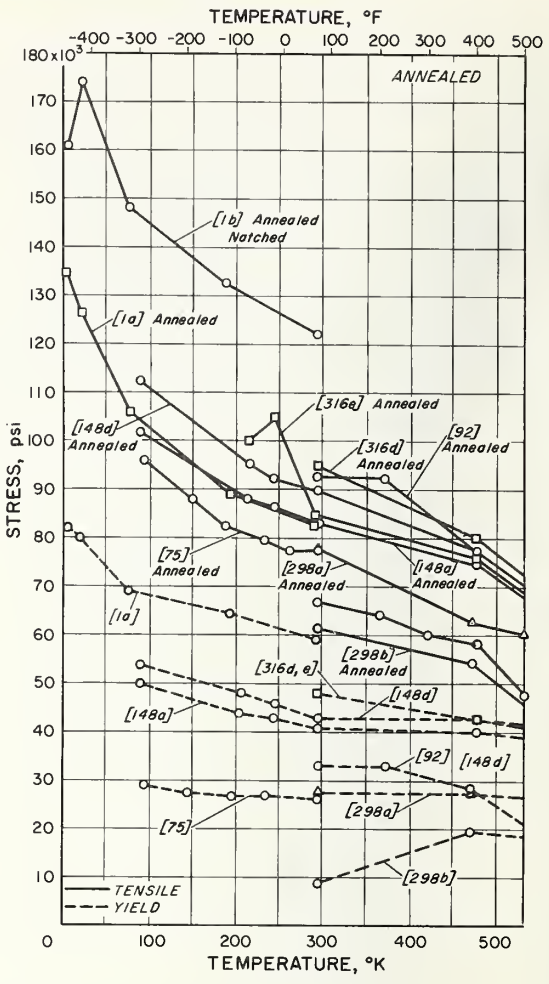
Modulus of Rigidity of Cu-Sn (Phosphor Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
241	Reduced 37%, grade C.	92.0		8.0				241
350	Cold drawn - after annealing, grade A. Wire sample - 0.091 inch diam., tested in torsion.	96.0		3.7				350

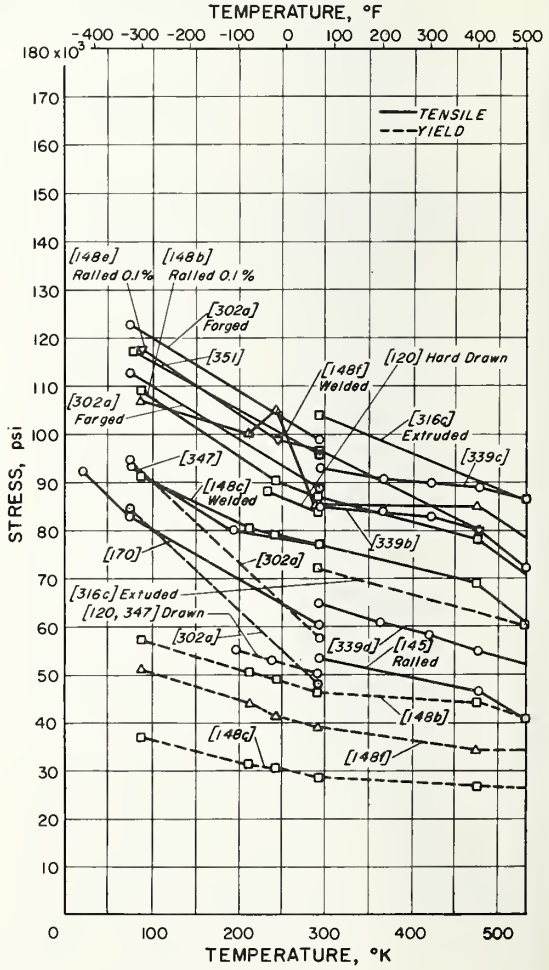


Tensile and Yield Strength of Cu-Al (Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed - 0.03mm. G.S. - R_B = 97, grade D, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, Y.S. -0.2% offset.	91.0			6.6		2.1Fe	1
1b	Notched sample - 0.005 ± 0.0005 inch notch radius - 0.250 inch diam. at notch (K_T = 5.0). Other specifications same as 1a.	91.0			6.6		2.1Fe	1
75	Annealed, bar supplied - 0.25 inch diam. Y.S. - 0.1% offset.	91.1	1.0		7.3		0.4Mn, 0.1Fe	75
92	Annealed 850°C - 1/2 hr. - air cooled - after cold drawing. Y.S. - 0.2% offset.	Bal	0.1		9.8	0.5	3.9Fe, 3.0Mn	92
148a	Alloy grade 8, annealed 1150°F, "quickly" cooled. Bar sample - reduced section: 2 inches long X 0.505 inch diam. - polished with 00 emery, Y.S. - 0.5% offset.	89.6			7.8		2.6Fe	148
148d	Annealed 1150°F - "quickly" cooled, grade 15. Bar sample - reduced section: 2 inches long X 0.505 inch diam. - polished with 00 emery, Y.S. - 0.5% offset.	87.2	0.1		9.2	0.4	3.1Fe	148
298a	Annealed. Strip sample, held 30 minutes at test temp., Y.S. - 0.1% offset.	90.2			9.7			298
298b	Annealed. Strip sample - 0.08 inch thick, held 15 minutes at test temp., crosshead speed = 2 inches/minute, Y.S. - 0.1% offset.	92.8			7.1			298
316a	Annealed - after cold drawing. Tube sample (condenser) - 0.75 X 0.049 inch.	94.9			5			316
316d	Annealed - R_B = 83 - after extruding and drawing. Y.S. - 0.5% offset.	87.2	0.1		9.2	0.4	3.1Fe	316
316e	Annealed - R_B = 81 - after extruding and drawing. Y.S. - 0.5% offset.	89.6			7.8		2.6Fe	316

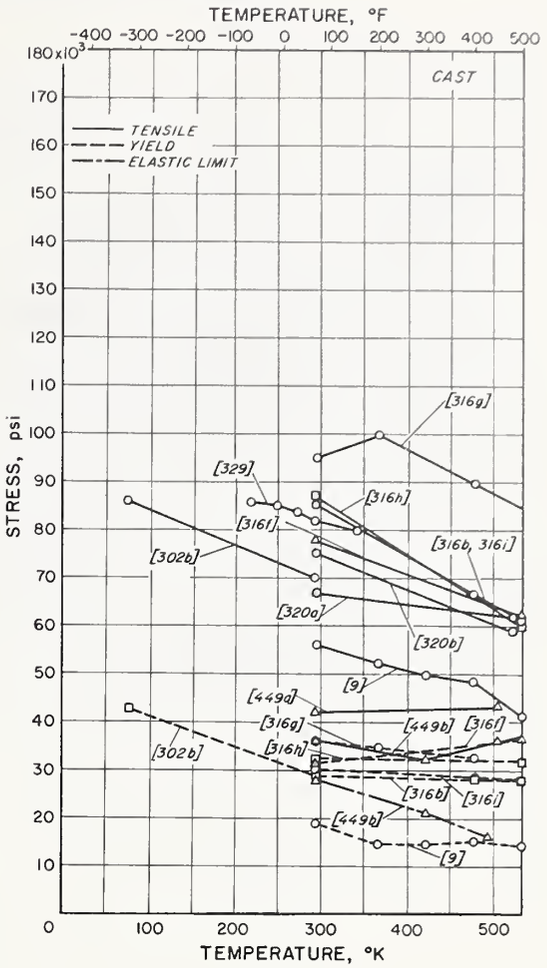


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
120	Hard drawn, bar supplied - 1/2 inch diam. Bar sample - 0.375 inch diam., Y.S. - 0.2% offset.	89.6			9.8		0.6Fe	120
145	Rolled bar - bar supplied - 1 inch diam.	Bal			7.2		0.1Fe	145
148b	Cold rolled 0.1% - after first annealing 1150°F - then cold drawing 19% - then re-annealing 1150°F and "quickly" cooling, grade A. Bar sample - reduced section: 2 inches long X 0.505 inch diam. - polished with 00 emery, Y.S. - 0.5% offset.	89.6			7.8		2.6Fe	148
148c	Carbon arc welded, nominal weld composition listed, grade 8. Bar sample - reduced section: 2 inches long X 0.505 inch diam. - polished with 00 emery, Y.S. -0.5% offset.	90.0	0.1		8.0	0.4	1.4Fe, 0.4Si	148
148e	Cold rolled 0.1% - after first annealing 1150°F - then cold drawing 3% - then re-annealing 1150°F and "quickly" cooling, grade 15. Bar sample - reduced section: 2 inches long X 0.505 inch diam. - polished with 00 emery, Y.S. - 0.5% offset.	87.2	0.1		9.2	0.4	3.1Fe	148
148f	Carbon arc welded, nominal weld composition listed, grade 15. Bar sample - reduced section: 2 inches long X 0.505 inch diam. - polished with 00 emery, Y.S. - 0.5% offset.	86.0			9.4	0.4	3.8Fe, 0.4Si	148
170	Bar sample - 0.118 inch diam.	95			5			170
302a	Forged, Y.S. - 0.2% offset.	88			9		3Fe	302
316c	Extruded - R_B = 96, 3/4 inch diam. wrought bar supplied, Y.S. - 0.2% offset.	86.3			9.5		3.5Fe, 0.3Si	316
339b	1 hr. at test temp.	Bal			9.9			339
339c	1 hr. at test temp.	Bal			9.9		1Mn	339
339d	1 hr. at test temp.	Bal			6.7			339
347	3/4 inch bar supplied, nominal composition listed. Bar sample - 0.505 inch diam., average of 2 tests at 70°F and -108°F - one test at -320°F, Y.S. - 0.2% offset.	Bal		0.5	9	0.5	~1Fe	347
351	Forged. Bar sample - 0.505 inch diam.							351



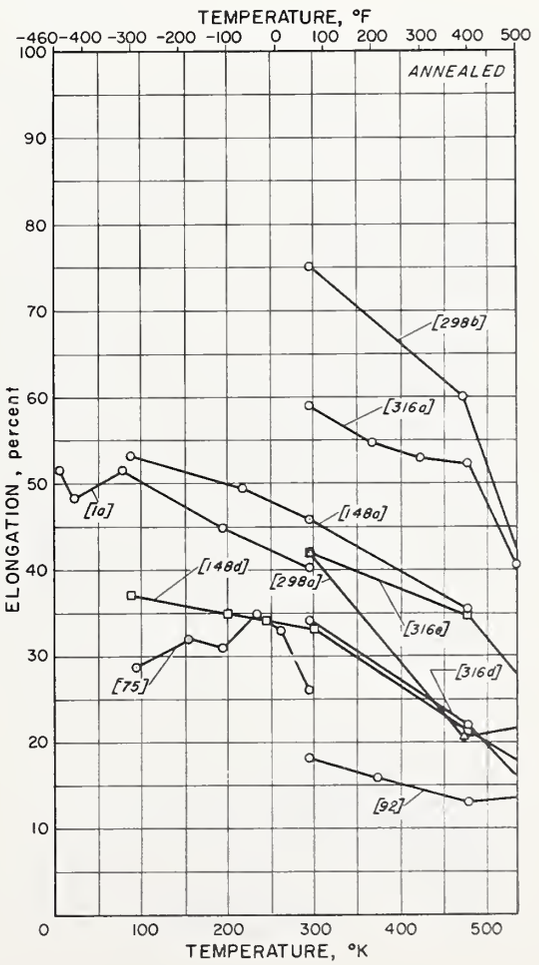
Tensile and Yield Strength of Cu-Al (Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
9	Die cast - R_B = 24. Bar sample - 0.505 inch diam. X 6 inches long, Y.S. - 0.2% offset.	91.5			7.7		0.7Fe	9
302b	Cast. Y.S. - 0.2% offset.	88			9		3Fe	302
316b	Die cast, 1/2 inch diam., bar supplied. Y.S. - 0.2% offset.	89.0			10.1		1.0Fe	316
316f	Sand cast (double keel blocks) - R_B = 90. Y.S. -0.2% offset.	85.8			11.1		2.8Fe, 0.2Si	316
316g	Sand cast - R_B = 88. Y.S. - 0.2% offset.	Bal			10.6	0.4	3.6Fe	316
316h	Sand cast (double keel blocks) - R_B = 90. Machined sample, Y.S. - 0.2% offset.	85.3			10.8		3.6Fe, 0.1Si	316
316i	Sand cast (double keel blocks) - R_B = 86. Machined sample, Y.S. - 0.2% offset.	85.4			10.1		4.4Fe, 0.1Mn, 0.1Si	316
320a	Sand cast. Bar sample - reduced section: 2 inches long X 0.357 inch diam., temp. gradient 2-3°C, held at temp. about 30 minutes prior to test.	90.1			9.9			320
320b	Sand cast. Same test parameters as 320a.	89.2			7.9		2.8Fe	320
329	Gravity die cast, 0.564 inch diam., bar supplied.	87.5			9.6	0.2	2.5Fe, 0.1Mn	329
449a	Cast.	88.9	0.2		9.7		0.6Fe, 0.4Sn, 0.2Pb	449
449b	Cast.	94.9			4.9		0.1Pb, 0.1Fe	449



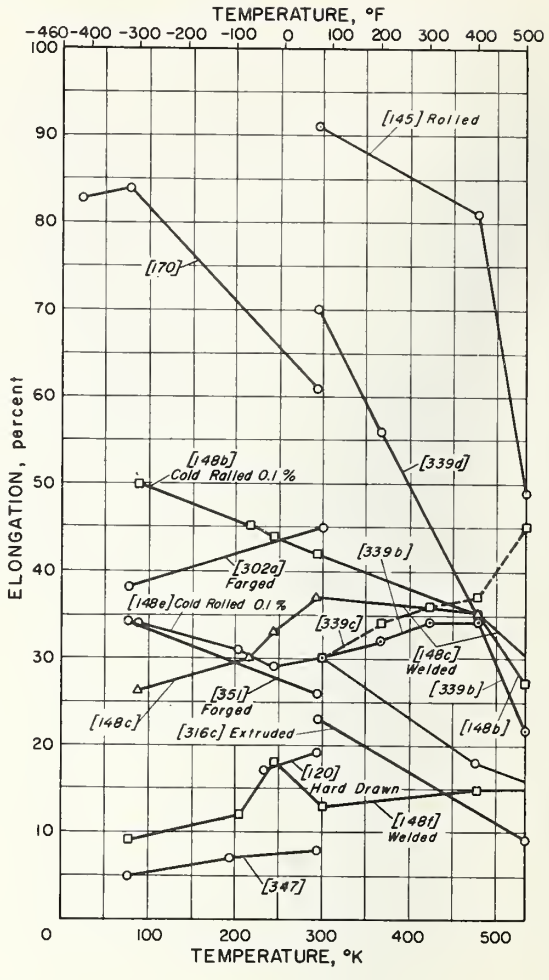
Tensile Elongation of Cu-Al (Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed - 0.036mm. G.S. - R_B = 97, grade D, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, 1 inch G.L.	91.0			6.6		2.1Fe	1
75	Annealed. Bar sample - 0.25 inch diam., 2 inch G.L.	91.1	1.0		7.3		0.4Mn	75
92	Annealed 850°C - 1/2 hr. - air cooled - after cold drawing. 2 inch G.L.	Bal	0.1		9.8	0.5	3.9Fe, 3.0Mn	92
148a	Annealed 1150°F - "quickly" cooled, grade 8. Bar sample, reduced section: 2 inches long X 0.505 inch diam. - polished with 00 emery. 2 inch G.L.	89.6			7.8		2.6Fe	148
148d	Annealed 1150°F - "quickly" cooled, grade 15. Sample specifications same as 148a.	87.2	0.1		9.2	0.4	3.1Fe	148
298a	Annealed strip. Held 30 minutes at test temp., 2 inch G.L.	90.2			9.7			298
298b	Annealed. Strip sample - 0.08 inch thick. Held 15 minutes at test temp., crosshead speed = 2 inches/minute, 2 inch G.L.							298
316a	Annealed - after cold drawing. Tube sample (condenser) - 0.75 X 0.049 inch, 2 inch G.L.	94.9			5			316
316d	Annealed - R_B = 83 - after extruding and drawing. Bar sample, 2 inch G.L.	87.2	0.1		9.2	0.4	3.1Fe	316
316e	Annealed - R_B = 81 - after extruding and drawing. Bar sample, 2 inch G.L.	89.6			7.8		2.6Fe	316

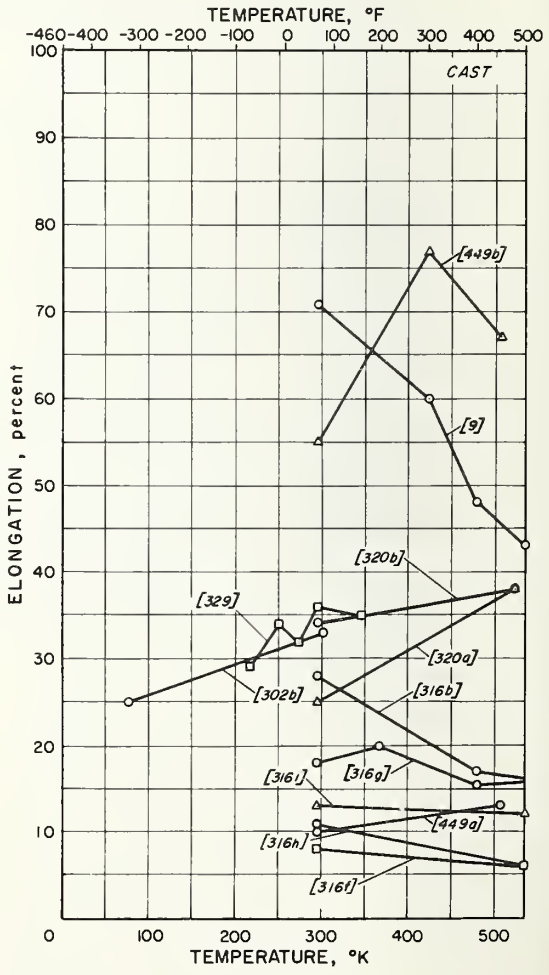


Tensile Elongation of Cu-Al (Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
120	Hard drawn, bar supplied - 1/2 inch diam. Bar sample - 0.375 inch diam., 2 inch G.L.	89.6			9.8		0.6Fe	120
145	Rolled, bar supplied - 1 inch diam. 2 inch G.L.				7.2		0.1Fe	145
148b	Cold rolled 0.1% - after first annealing 1150°F - then cold drawing 19% - then re-annealing 1150°F and "quickly" cooling grade 8. Bar sample, reduced section: 2 inches long X 0.505 inch diam. - polished with 00 emery, 2 inch G.L.	89.6			7.8		2.6Fe	148
148c	Carbon arc welded, nominal weld composition listed, grade 8. Sample specifications same as 148b. 2 inch G.L.	90.1	0.1		8.0	0.4	1.4Fe	148
148e	Cold rolled 0.1% - after first annealing 1150°F - then cold drawing 3% - then re-annealing 1150°F and "quickly" cooling, grade 15. Bar sample, 2 inch G.L.	87.2	0.1		9.2	0.4	3.1Fe	148
148f	Carbon arc welded, nominal weld composition listed, grade 15. Sample specifications same as 148b. 2 inch G.L.	86.0			9.4	0.4	3.8Fe	148
170	Bar sample - 0.118 inch diam., 1.18 inch G.L.	95			5			170
302a	Forged. 2 inch G.L.	88			9		3Fe	302
316c	Extruded - R_B = 96, 3/4 inch diam. wrought bar supplied. 2 inch G.L.	86.3			9.5		3.5Fe, 0.3Si	316
339b	1 hr. at test temp., 2 inch G.L.	Bal			9.9			339
339c	1 hr. at test temp., 2 inch G.L.	Bal			9.9		1Mn	339
339d	1 hr. at test temp., 2 inch G.L.	Bal			6.7			339
347	Nominal composition listed, bar supplied - 3/4 inch diam. Bar sample - 0.505 inch diam., only 1 test at -320°F, 2 inch G.L.	Bal		0.5	9	0.5	~1Fe	347
351	Forged, Bar sample - 0.505 inch diam., 2 inch G.L.							351

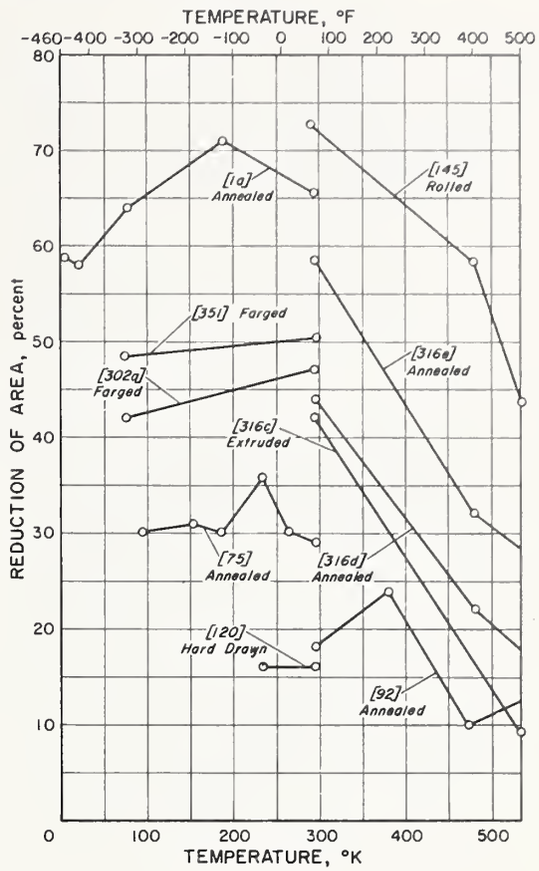


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
9	Die cast - R_B = 24. Bar sample - 6 inches long X 0.505 inch diam., 2 inch G.L.	91.5			7.7		0.7Fe	9
302b	Cast. 2 inch G.L.	88			9		3Fe	302
316b	Die cast, bar supplied - 1/2 inch diam., 2 inch G.L.	89.0			10.1		1.0Fe	316
316f	Sand cast (double keel blocks) - R_B = 90. 2 inch G.L.	85.8			11.1		2.8Fe, 0.2Si	316
316g	Sand cast - R_B = 88. 2 inch G.L.	Bal			10.6	0.4	3.6Fe	316
316h	Sand cast (double keel blocks) - R_B = 90. Machined sample, 2 inch G.L.	85.3			10.8		3.6Fe, 0.1Si	316
316i	Sand cast (double keel blocks) - R_B = 86. Machined sample, 2 inch G.L.	85.4			10.1		4.4Fe, 0.1Mn, 0.1Si	316
320a	Sand cast. Bar sample - 0.357 inch diam., strain rate = 0.025 inch/inch/minute, held at temp. about 30 minutes prior to testing. 1.25 inch G.L.	90.1			9.9			320
320b	Sand cast. Other specifications same as 320a.	89.2			7.9		2.8Fe	320
329	Gravity die cast. Bar sample - 0.564 inch diam., 2 inch G.L.	87.5			9.6	0.2	2.5Fe, 0.1Mn	329
449a	Cast.	88.9	0.2		9.7		0.6Fe, 0.4Sn 0.2Pb	449
449b	Cast.	94.9			4.9		0.1Pb, 0.1Fe	449

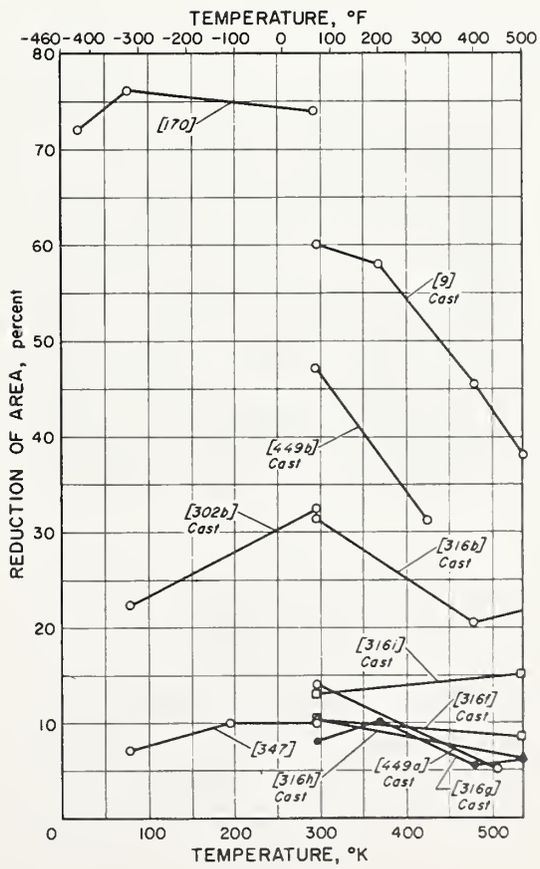


Tensile Reduction of Area of Cu-Al (Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed - 0.036mm. C.S. - R_B = 97, grade D, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute.	91.0			6.6		2.1Fe	1
75	Annealed. Bar sample - 0.25 inch diam.	91.1	1.0		7.3		0.4Mn	75
92	Annealed 850°C - 1/2 hr. - air cooled - after cold drawing.	Bal	0.1		9.8	0.5	3.9Fe, 3.0Mn	92
120	Hard drawn, bar supplied - 1/2 inch diam. Bar sample - 0.375 inch diam.	89.6			9.8		0.6Fe	120
145	Rolled, bar supplied - 1 inch diam.	Bal			7.2		0.1Fe	145
302a	Forged.	88			9		3Fe	302
316c	Extruded - R_B = 96, 3/4 inch diam. wrought bar supplied.	86.3			9.5		3.5Fe, 0.3Si	316
316d	Annealed - R_B = 83 - after extruding and drawing. Bar sample.	87.2	0.1		9.2	0.4	3.1Fe	316
316e	Annealed - R_B = 81 - after extruding and drawing. Bar sample.	89.6			7.8		2.6Fe	316
351	Forged. Bar sample - 0.505 inch diam.	Bal						351

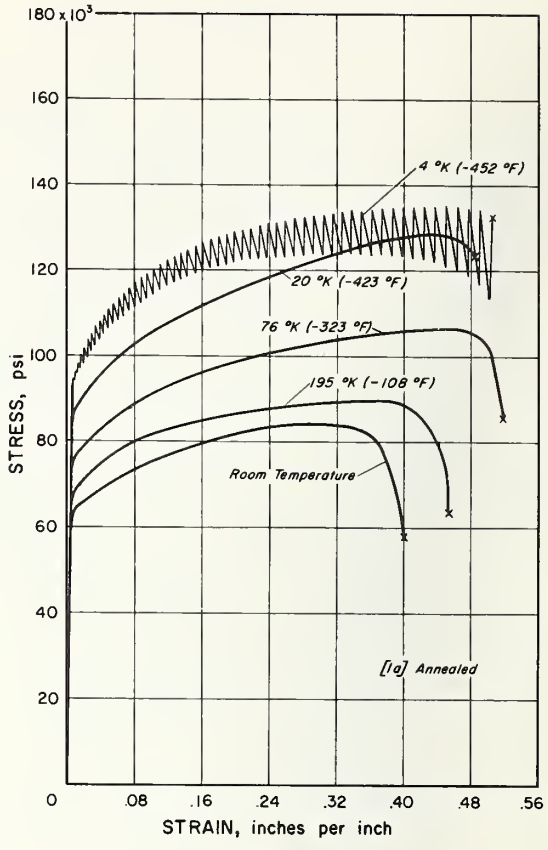


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
9	Die cast. Bar sample - 0.505 inch diam.	91.5			7.7		0.7Fe	9
170	Bar sample - 0.118 inch diam.	95			5			170
302b	Cast.	88			9		3Fe	302
316b	Die cast. Bar sample - 1/2 inch diam.	89.0			10.0		1.0Fe	316
316f	Sand cast (double keel blocks) - R_B = 90.	85.8			11.1		2.8Fe, 0.2Si	316
316g	Sand cast - R_B = 88.	Bal			10.6	0.4	3.6Fe	316
316h	Sand cast (double keel blocks) - R_B = 90. Machined sample.	85.3			10.8		3.6Fe, 0.1Si	316
316i	Sand cast (double keel blocks) - R_B = 86. Machined sample.	85.4			10.1		4.4Fe, 0.1Mn, 0.1Si	316
347	3/4 inch bar stock, Nominal composition listed, bar supplied - 3/4 inch diam. Bar sample - 0.505 inch diam. Only 1 test at -320°F.	Bal		0.5	9	0.5	~1Fe	347
449a	Cast.	88.9	0.2		9.7		0.6Fe, 0.4Sn, 0.2Pb	449
449b	Cast.	94.9			4.9		0.1Pb, 0.1Fe	449



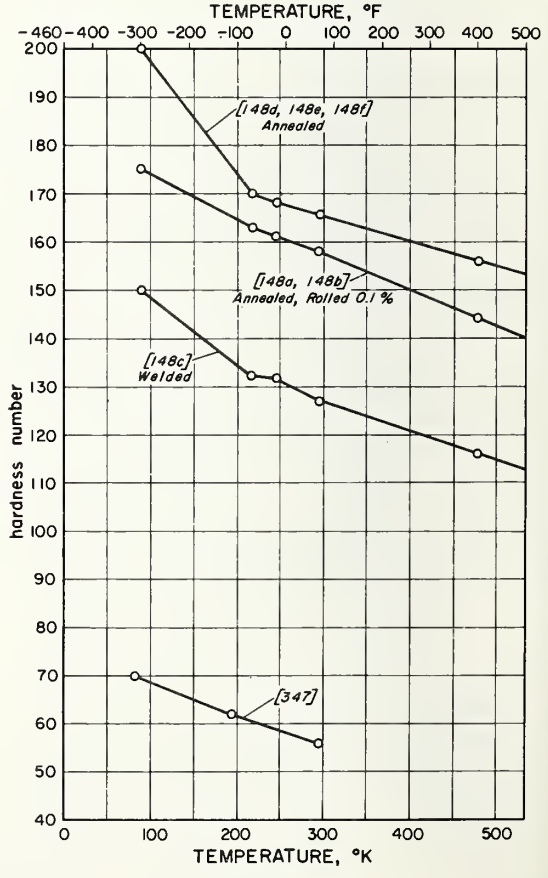
Tensile Stress-Strain Curves of Cu-Al (Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed - 0.036mm. G.S. - R_B = 97, grade D, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer, 1 inch G.L.	91.0			6.6		2.1Fe	1



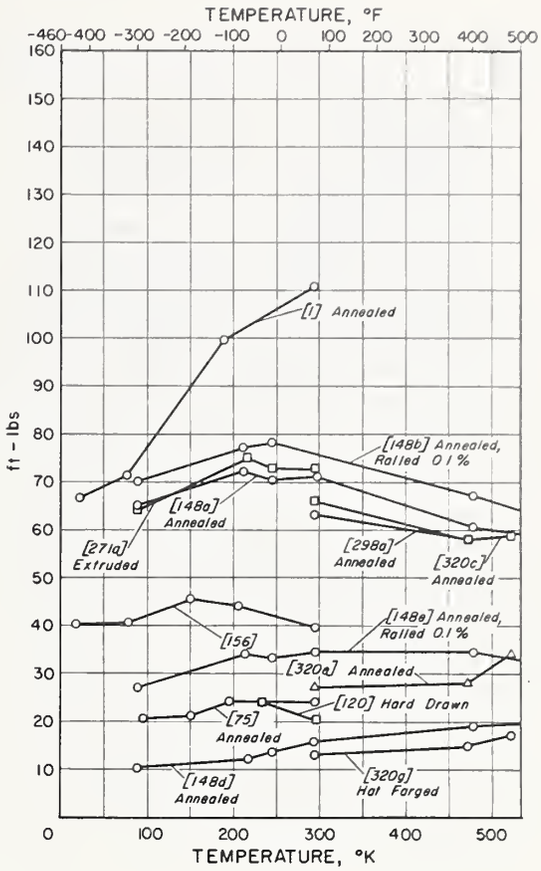
Hardness of Cu-Al (Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
148a	Annealed 1150°F - "quickly" cooled, grade 8. Sample - 1/2 inch thick, Brinell hardness: 10mm. Carboloy ball - 3000 kgm. load.	89.6			7.8		2.6Fe	148
148b	Cold rolled 0.1% - after first annealing 1150°F - then cold drawing 19% - then re-annealing 1150°F and "quickly" cooling, grade 8. Other specifications same as 148a.	89.6			7.8		2.6Fe	148
148c	Alloy grade 8, carbon arc welded, nominal weld composition listed, , grade 8. Other specifications same as 148a.	90.1			8.0	0.1	1.4Fe, 0.4Si	148
148d	Annealed 1150°F - "quickly" cooled, grade 15. Other specifications same as 148a.	87.2	0.1		9.2	0.4	3.1Fe	148
148e	Annealed 1150°F - "quickly" cooled - after first annealing 1150°F - then cold drawing 3%, grade 15. Other specifications same as 148a.	87.2	0.1		9.2	0.4	3.1Fe	148
148f	Carbon arc welded, nominal weld composition listed, grade 15. Other specifications same as 148a.	86.0			9.4	0.4	3.8Fe, 0.4Si	148
347	Nominal composition listed, bar supplied - 3/4 inch diam. Sample - 1/2 inch thick - 2/0 grit paper finish, Vickers pyramid hardness.	Bal		0.5	9.0	0.5	~1Fe	347

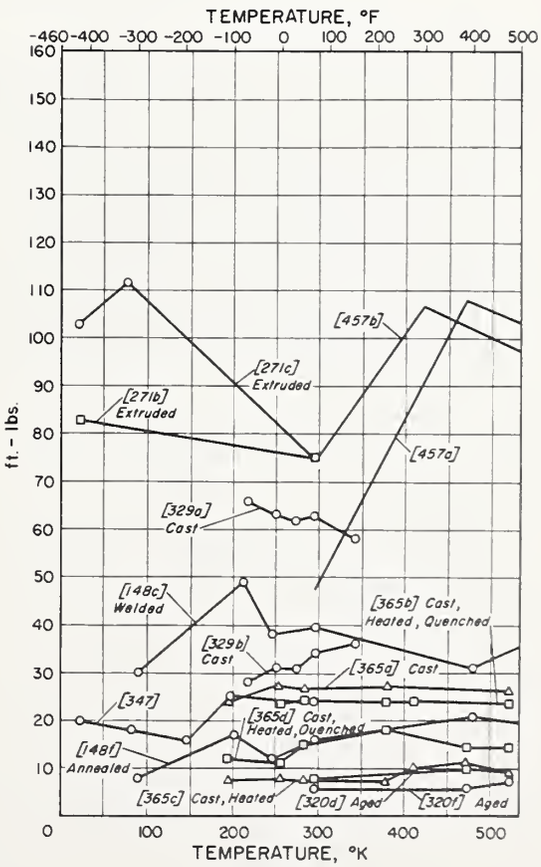


Impact Energy of Cu-Al (Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
1	Annealed - 0.036mm. G.S. - R_B = 97, grade D, bar supplied - 3/4 inch diam. Charpy V-notch, 95% fracture- all temps., sample contained in paper boat for 20°K tests.	91.0			6.6		2.1Fe	1
75	Annealed, bar supplied - 1 inch diam. Izod.	91.1	1.0		7.3		0.4Mn	75
120	Hard drawn, bar supplied - 1/2 inch diam. Izod.	89.6			9.8		0.6Fe	120
148a	Annealed 1150°F - "quickly" cooled, bar supplied, grade 8. Charpy V-notch, 3 tests/temp.	89.6			7.8		2.6Fe	148
148b	Cold rolled 0.1% - after first annealing 1150°F - then cold drawing 19% - then re-annealing 1150°F and "quickly" cooling, grade 8. Charpy V-notch, 3 tests/temp.	89.6			7.8		2.6Fe	148
148d	Annealed at 1150°F - "quickly" cooled, grade 15. Charpy V-notch, 3 tests/temp.	87.2	0.1		9.2	0.4	3.1Fe	148
148e	Cold rolled 0.1% - after first annealing 1150°F - then cold drawing 3% - then re-annealing 1150°F and "quickly" cooling, grade 15. Charpy V-notch.	87.2	0.1		9.2	0.4	3.1Fe	148
156	Room temp: Vickers hardness = 152 to 172, rolled 5/8" diam. bar supplied, grade B. Charpy keyhole.							156
271a	Extruded - Brinell hardness (3000 kgm.) = 155, grade 8, bar supplied - 2 inch diam. Charpy V-notch.	89.6			7.8		2.6Fe	271
298a	Annealed 800°C - 1 hr. - rapidly cooled - after extruding. Charpy V-notch.	89.0			10.1			298
320c	Normalized (quenched from about 700°C), extruded bar supplied. Izod, sample held at temp. 30 minutes prior to test.	89.9			10.1			320
320e	Normalized (quenched from about 700°C), extruded bar supplied. Izod, sample held at temp. 30 minutes prior to test.	87.1			10.1		2.8Fe	320
320g	Hot forged. Izod, sample held at temp. 30 minutes prior to test	85.8			10.0		4.2Fe	320

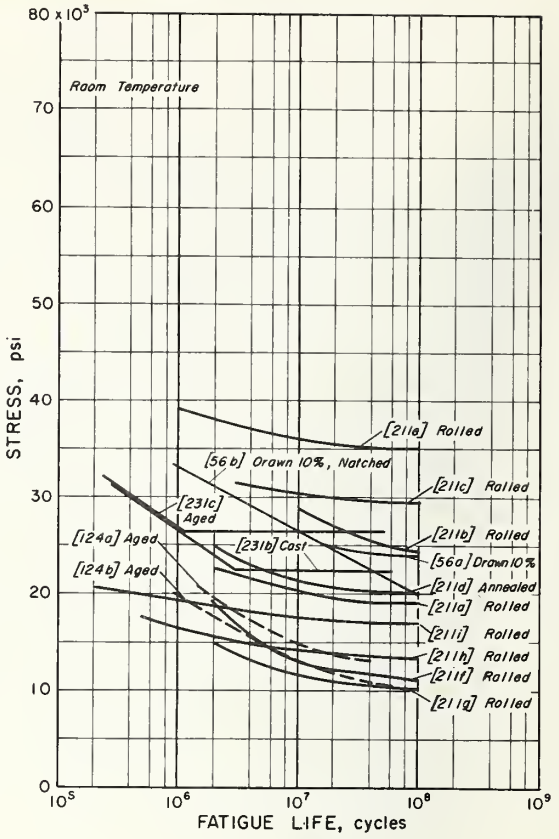


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
148c	Carbon arc welded, nominal composition of weld metal listed, grade 8. Charpy V-notch, 3 tests/temp.	90.0			8.0	0.1	1.4Fe, 0.4Si	148
148f	Carbon arc welded, nominal weld composition listed, bar supplied, grade 15. Charpy V-notch.	86.0			9.4	0.4	3.8Fe, 0.4Si	148
271b	Room temp.: U.T.S. = 76,000 psi - Brinell hardness (3000 kgm.) = 153, grade 8, plate supplied - 3/8 inch thick. Charpy V-notch.	90.7			6.8		2. Fe	271
271c	Room temp.: U.T.S. = 78,800 psi - Brinell hardness (3000 kgm.) = 130, grade 8, plate supplied - 3/4 inch thick. Charpy V-notch.	90.3			7.0	0.2	2.5Fe	271
320d	Stabilized (held at about 500°C), extruded bar supplied. Izod, sample held at temp. 30 minutes prior to test.	89.9			10.1			320
320f	Stabilized (held at about 500°C). Other specifications same as 320d.	87.1			10.1		2.8Fe	320
329a	Gravity die cast. Unnotched specimen: 60mm. X 1/4 inch X 1/4 inch.	87.5			9.6	0.2	2.5Fe, 0.1Mn	329
329b	Gravity die cast. Modified Charpy V-notch: 60 X 10 X 10 mm. - 0.25mm. notch radius - 45° V-notch - 2mm. deep.	87.5			9.6	0.2	2.5Fe, 0.1Mn	329
347	Nominal composition listed, bar supplied - 3/4 inch diam. Charpy V-notch sample contained in paper boat for low temp. tests.	Bal		0.5	9.0	0.5	~1.0Fe	347
365a	As cast. Modified Charpy V-notch: 10 X 10 X 60mm. - 0.25mm. notch radius - 45° V-notch - 2mm. deep, sample at temperature 1/2 hr. prior to test.	Bal			10.1			365
365b	Cast - then heated to 950°C - water quenched. Other specifications same as 365a.	Bal			10.1			365
365c	Cast - then heated to 950°C - furnace cooled. Other specifications same as 365a.	Bal			10.1			365
365d	Cast - then heated to 950°C - individually water quenched. Other specifications same as 365a.	Bal			10.1			365
457a	Assumed type, Mesnager; U-notch: 0.079 inch deep X 0.079 inch wide; cross section - 0.394 X 0.394 inch, point data not presented by author.	90.0			9.8		0.2Fe	457
457b	Specifications same as 457a.	88.5			7.5		3.7Fe, 0.2Mn, 0.1Sn	457

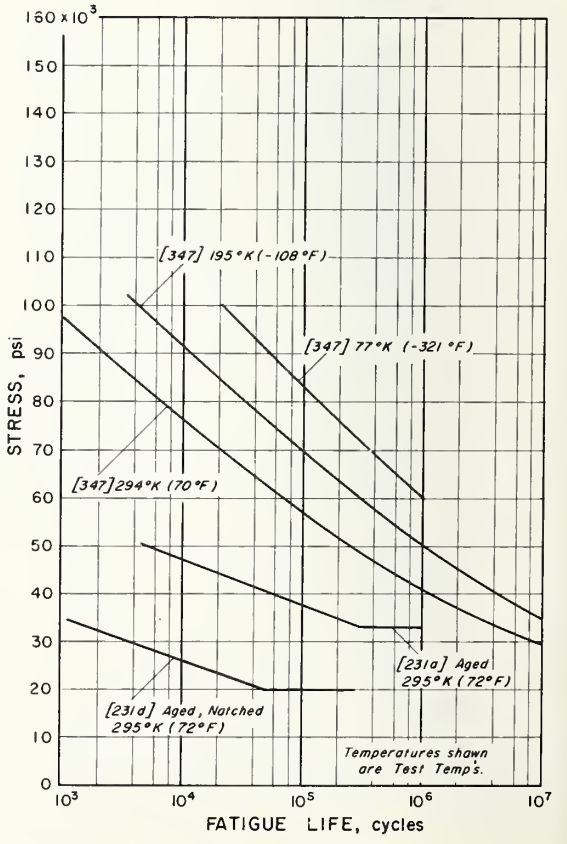


Fatigue Behavior of Cu-Al (Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
56a	Drawn 10%, room temp.: U.T.S. = 93,000 psi - Y.S. = 53,000 psi (0.2% offset), bar supplied - 0.565 inch diam. Bar sample - 4 inches long - 0.5 inch diam. reduced to 0.3 inch diam. in center - polished 4/0 emery paper, rotating cantilever (Krause).	87.8			9.6		2.0Fe, 0.5Te	56
56b	Notched sample: 0.30 inch diam. at notch - 60° V-notch. Other specifications same as 56a.	87.8			9.6		2.0Fe, 0.5Te	56
124a	Heated 850°C - water quenched - then tempered at 625°C - slowed cooled, room temp.: U.T.S. = 80,000 psi - Brinell hardness = 150. Bar sample - 0.275 inch diam., rotating beam - 2200 c.p.m.	89.5	1.4		8.9		0.2Fe	124
124b	Tested in salt spray (3% salt in water). Other specifications same as 124a.	89.5	1.4		8.9		0.2Fe	124
211a	Rolled room temp.: U.T.S. = 71,900 psi. Bar sample - 0.3 to 0.4 inch diam., rotating cantilever - 1800 r.p.m., R = -1, data spread = ± 9%.	94.3			5.6			211
211b	Rolled, room temp.: U.T.S. = 86,800 psi. Data spread = ± 7%. Other specifications same as 211a.	90.8			9.1			211
211c	Rolled, room temp.: U.T.S. = 83,400 psi. Data spread = ± 7%. Other specifications same as 211a.	89.9			10.0			211
211d	Annealed 1200°F - 60 minutes - furnace cooled, room temp.: U.T.S. = 62,300 psi. Data spread = ± 2%. Other specifications same as 211a.	89.9			10.0			211
211e	Rolled, room temp.: U.T.S. = 99,000 psi. Data spread = ± 6%. Other specifications same as 211a.	86.7			10.4		2.9Fe	211
211f	Alternating torsion - 2140 c.p.m., R = -1, data spread = ± 2%. Other specifications same as 211a.	94.3			5.6			211
211g	Rolled, room temp.: U.T.S. = 86,800 psi. Other specifications same as 211f.	90.8			9.1			211
211h	Rolled, room temp.: U.T.S. = 83,400 psi. Alternating torsion - 2140 c.p.m., R = -1, data spread = ± 6%.	89.9			10.0			211
211i	Rolled, room temp.: U.T.S. = 99,000 psi. Alternating torsion - 2140 c.p.m., R = -1, data spread = ± 2%.	86.7			10.4		2.9Fe	211
231b	Cast. Bar sample - 0.375 inch diam. - polished, rotating beam (R.R.Moore) - 1500r.p.m., R = -1, data spread = ±2%.	90.2			9.8			231
231c	Cast, then heated 1650°F - water quenched - reheated to 1200°F - 1/2 hr. - furnace cooled. Other specifications same as 231b.	90.2			9.8			231

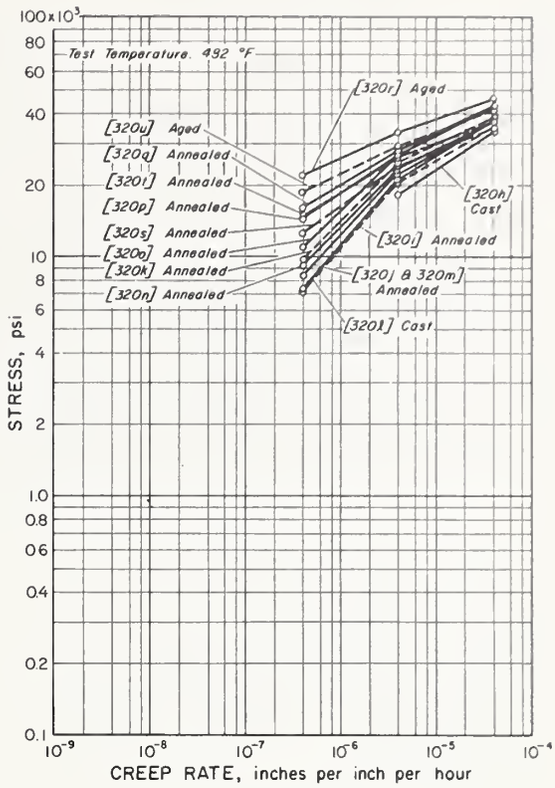


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
231a	Aged, heated 1650°F - water quenched - then reheated 1150°F - 1/2 hr. - furnace cooled, room temp.: U.T.S. = 77,530 psi - R_B = 104, extruded bar supplied. Bar sample - 0.375 inch diam. - polished, rotating beam (R.R.Moore) - 1500r.p.m., R = -1, data spread = ± 2%.	89.8			10.1		0.1Fe	231
231d	Aged, condition specifications same as 231a, Notched sample: 0.371 inch diam. at notch - 0.010 inch notch radius (K_T = 4.3), 60° notch angle. Test specifications same as 231a.	89.8			10.1		0.1Fe	231
347	Nominal composition listed, 3/4 inch diam. bar supplied. Bar sample - 0.5 inch diam. - "highly" polished reduced section, reciprocating cantilever beam (Krause).	Bal		0.5	9.0	0.5	~1Fe	347



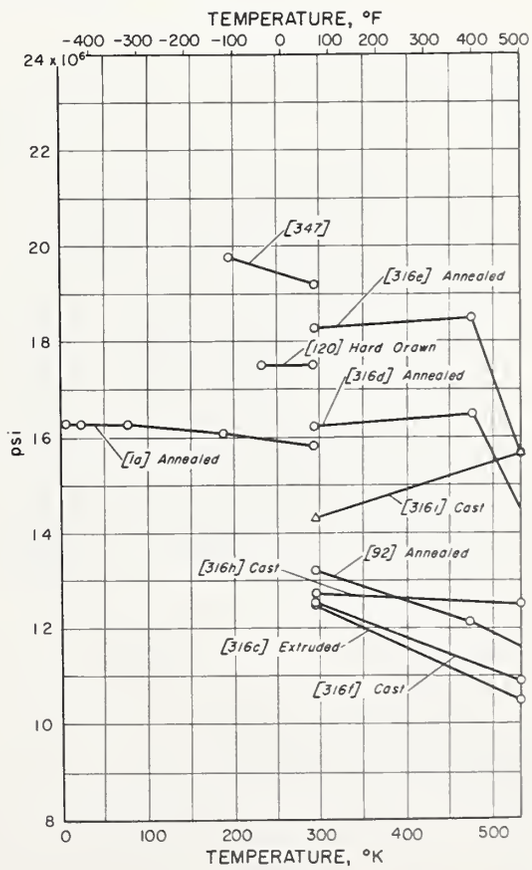
Creep Behavior of Cu-Al (Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
320h	Sand cast. Sample - 5 inches long - 0.1 square inch reduced section, ± 0.0001 inch extensometer sensitivity, constant load, test data taken after 5 days under load.	89.9			10.1			320
320i	Normalized (heated 825°C - 1 hr. - air cooled). Other specifications same as 320h.	89.5			10.5			320
320j	Normalized and held 4 weeks at 250°C. Other specifications same as 320h.	89.5			10.5			320
320k	Stabilized (heated 500°C - 3 days - slowly cooled). Other specifications same as 320h.	89.5			10.5			320
320l	Specifications same as 320h.	86.9			9.7		3.4Fe	320
320m	Specifications same as 320i.	87.1			10.1		2.8Fe	320
320n	Normalized. Held 3 weeks at 250°C. Other specifications same as 320h.	87.1			10.1		2.8Fe	320
320o	Specifications same as 320k.	87.1			10.1		2.8Fe	320
320p	Test data taken after 40 days under load. Other specifications same as 320i.	87.1			10.1		2.8Fe	320
320q	Test data taken after 40 days under load. Other specifications same as 320k.	87.1			10.1		2.8Fe	320
320r	Test data taken after 40 days under load. Other specifications same as 320k.	87.1			10.1		2.8Fe	320
320s	Test data taken after 40 days under load. Other specifications same as 320i.	89.5			10.5			320
320t	Test data taken after 40 days under load. Other specifications same as 320j.	89.5			10.5			320
320u	Test data taken after 40 days under load. Other specifications same as 320k.	89.5			10.5			320



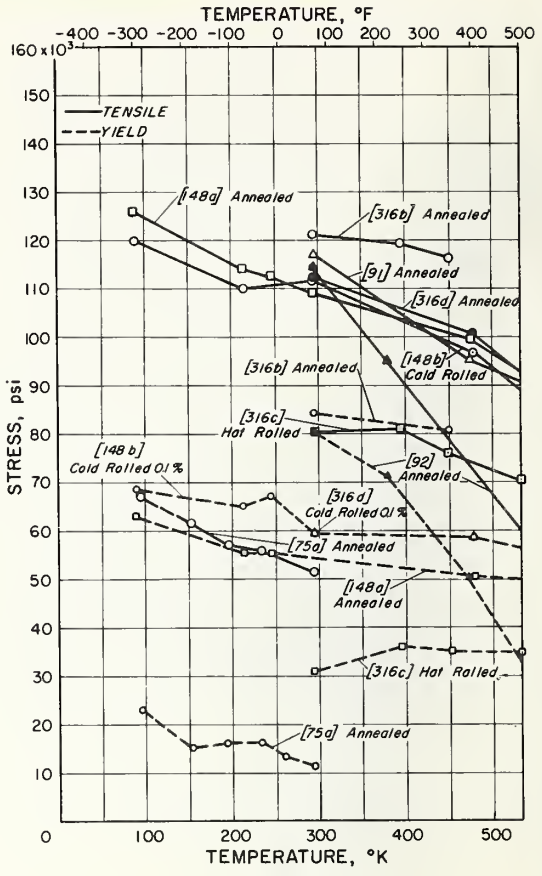
Modulus of Elasticity of Cu-Al (Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Annealed - 0.036mm. G.S. - R_B = 97, grade D, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.25 inch diam., Young's modulus derived from stress vs. strain curves, 1 inch G.L.	91.0			6.6		2.1Fe	1
92	Annealed 850°C - 1/2 hr. - air cooled - after cold drawing.	Bal	0.1		9.8	0.5	3.9Fe, 3.0Mn	92
120	Hard drawn, bar supplied - 1/2 inch diam. Bar sample - 0.375 inch diam.	89.6			9.8		0.6Fe	120
316c	Extruded - R_B = 96, 3/4 inch wrought bar supplied.	86.3			9.5		3.5Fe, 0.3Si	316
316o	Annealed - R_B = 83 - after extruding and drawing. Bar sample.	87.2	0.1		9.2	0.4	3.1Fe	316
316e	Annealed - R_B = 81 - after extruding and drawing. Bar sample.	89.6			7.8		2.6Fe	316
316f	Sand cast (double keel blocks) - R_B = 90. Machined sample.	85.8			11.1		2.8Fe, 0.2Si	316
316h	Sand cast (double keel blocks) - R_B = 90. Machined sample.	85.3			10.8		3.6Fe, 0.1Si	316
316i	Sand cast (double keel blocks) - R_B = 86. Machined sample.	85.4			10.1		4.4Fe, 0.1Mn 0.1Si	316
347	Nominal composition listed, bar supplied - 3/4 inch diam. Bar sample - 0.505 inch diam., same specimen used at both temps.	Bal		0.5	9	0.5	~1.0Fe	347

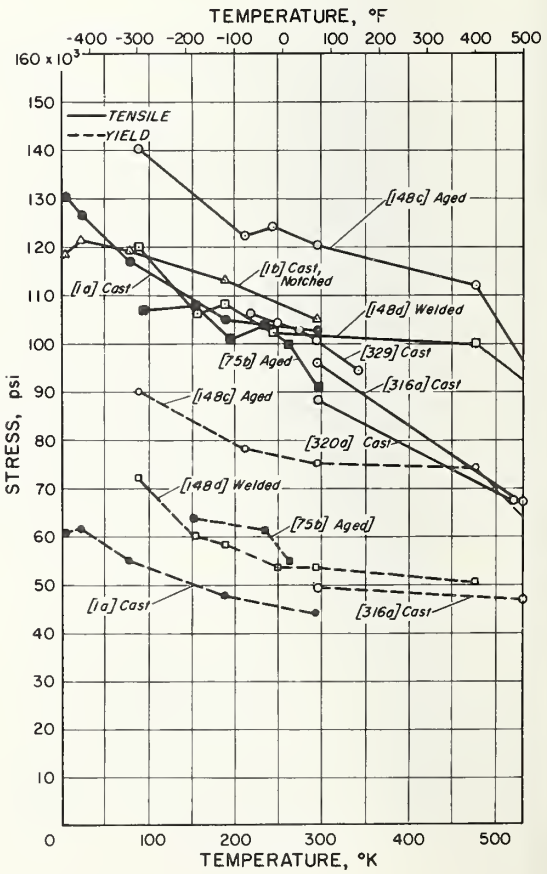


Tensile and Yield Strength of Cu-Al-Ni (Nickel Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
75a	Annealed 900°C - quenched. Bar sample - 0.25 inch diam., yield point.	92.3			1.7	5.9		75
91	Annealed 850°C - 1/2 hr. - air cooled - after cold drawing. Y.S. - 0.2% offset.	Bal			10.2	4.7	4.1Fe, 0.1Mn	91
92	Annealed 850°C - 1/2 hr. - air cooled - after cold drawing. Y.S. - 0.2% offset.	Bal			10.5	4.8	3.6Fe	92
148a	Annealed 1150°F - "quickly" cooled, grade 45. Bar sample - reduced section: 2 inches long X 0.505 inch diam. - polished with 00 emery cloth, Y.S. - 0.5% offset.	81.2	0.1		10.1	4.8	3.0Fe, 0.8Mn	148
148b	Cold rolled 0.1% - after first annealing 1150°F - then cold drawing 3% - then re-annealing 1150°F and "quickly" cooling. Other specifications same as 148a.	81.2	0.1		10.1	4.8	3.0Fe, 0.8Mn	148
316b	Annealed - R_B = 104. Bar sample, Y.S. - 0.2% offset.	Bal			9.7	4.8	2.6Fe, 1.0Mn	316
316c	Hot rolled, sheet supplied. Y.S. - 0.2% offset.	82.3			9.4	5.0	2.4Fe, 0.9Mn	316
316d	Annealed - R_B = 95 - after extruding and drawing, bar supplied. Y.S. - 0.5% offset.	81.2	0.1		10.1	4.8	3.0Fe, 0.8Mn	316

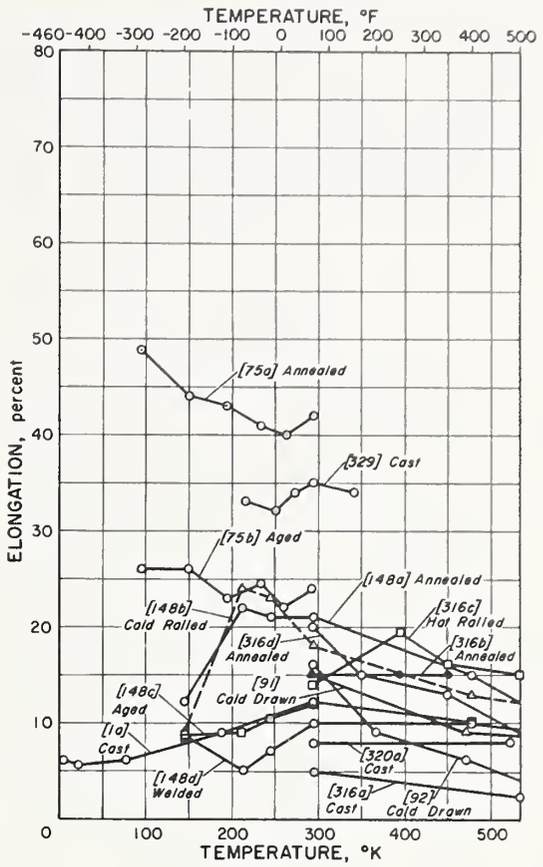


CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Sand cast - 0.036mm. G.S. - R_B = 93. Bar sample - reduced section: 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, Y.S. - 0.2% offset.	Bal			10.0	5.2	3.4Fe, 0.3Mn	1
1b	Notched sample: 0.250 inch diam. at notch - 0.005 ± 0.0005 inch notch radius (K_T = 5.0). Other specifications same as 1a.	Bal			10.0	5.2	3.4Fe, 0.3Mn	1
75b	Annealed 900°C - quenched - then reheated at 550°C for 2 hrs. Bar sample - 0.25 inch diam., yield point.	92.3			1.7	5.9		75
148c	Heated 1600°F - water quenched - then aged at 1200°F - air cooled, grade 45. Bar sample - reduced section: 2 inches long X 0.505 inch diam. - polished with 00 emery cloth, Y.S. - 0.5% offset.	81.2	0.1		10.1	4.8	3.0Fe, 0.8Mn	148
148d	Carbon arc welded, nominal weld composition listed. Other specifications same as 148c.	82.4			8.8	4.6	3.0Fe, 0.5Si, 0.8Mn	148
316a	Sand cast (double keel blocks) - R_B = 96. Machined sample, 0.2% offset.	79.7			11.5	4.5	4.3Fe, 0.1Si	316
320a	Sand cast. Bar sample - 0.357 inch diam., strain rate = 0.045 inch/inch/minute, held about 30 minutes at temp prior to test, temp. control about 2 to 3°C.	79.0			9.6	5.7	5.6Fe	320
329	Gravity die cast. Bar sample - 0.564 inch diam.	80.2			9.5	5.0	5.2Fe	329



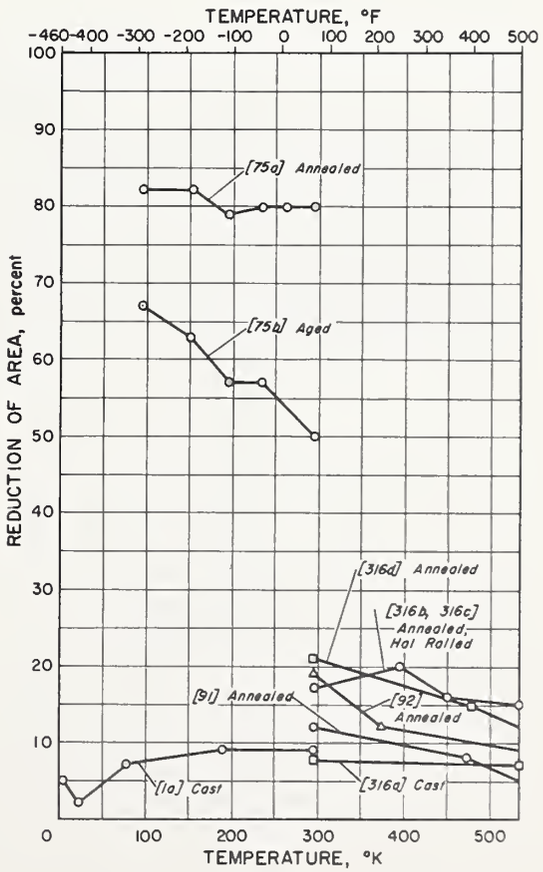
Tensile Elongation of Cu-Al-Ni (Nickel Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Sand cast - 0.025mm. G.S. - R_B = 93. Bar sample - reduced section: 1.5 inches long X 0.247 inch diam., crosshead speed = 0.02 inch/minute, 1 inch G.L.	Bal			10.0	5.2	3.4Fe, 0.3Mn	1
75a	Annealed at 900°C - quenched. Bar sample - 0.25 inch diam., 2 inch G.L.	92.3			1.7	5.9		75
75b	Annealed at 900°C - quenched - then reheated at 550°C for 2 hrs. Bar sample - 0.25 inch diam., 2 inch G.L.	92.3			1.7	5.9		75
91	Annealed 850°C - 1/2 hr. - air cooled - after cold drawing. 1.97 inch G.L.	Bal			10.2	4.7	4.1Fe, 0.1Mn	91
92	Annealed 850°C - 1/2 hr. - air cooled - after cold drawing. 2 inch G.L.	Bal			10.5	4.8	3.6Fe	92
148a	Annealed 1150°F - "quickly" cooled, grade 45. Bar sample - reduced section: 2 inches long X 0.505 inch diam. polished with 00 emery cloth, 2 inch G.L.	81.2	0.1		10.1	4.8	3.0Fe, 0.8Mn	148
148b	Cold rolled 0.1% - after first annealing 1150°F - then cold drawing 3% - then re-annealing 1150°F and "quickly" cooling. Other specifications same as 148a.	81.2	0.1		10.1	4.8	3.0Fe, 0.8Mn	148
148c	Heated 1650°F - water quenched - then aged at 1200°F - air cooled. Other specifications same as 148a.	81.2	0.1		10.1	4.8	3.0Fe, 0.8Mn	148
148d	Carbon arc welded, nominal weld composition listed. Other specifications same as 148a.	82.4			8.8	4.6	3.0Fe, 0.5Si, 0.8Mn	148
316a	Sand cast (double keel block) - R_B = 96. Machined sample, 2 inch G.L.	79.7			11.5	4.5	4.3Fe, 0.1Si	316
316b	Annealed - R_B = 104. Bar sample, 2 inch G.L.	Bal			9.7	4.8	1.0Mn, 2.6Fe	316
316c	Hot rolled. Sheet sample, 2 inch G.L.	82.3			9.4	5.0	2.4Fe, 0.9Mn	316
316d	Annealed - R_B = 95. - after extruding and drawing. Bar sample, 2 inch G.L.	81.2	0.1		10.1	4.8	3.0Fe, 0.8Mn	316
320a	Sand cast. Bar sample - 0.357 inch diam., strain rate = 0.025 inch/inch/minute, held about 30 minutes at temp. prior to test, temp. control about 2 to 3°C, 1.25 inch G.L.	79.0			9.6	5.7	5.6Fe	320
329	Gravity die cast. Bar sample - 0.564 inch diam., 2 inch G.L.	80.2			9.5	5.0	5.2Fe	329



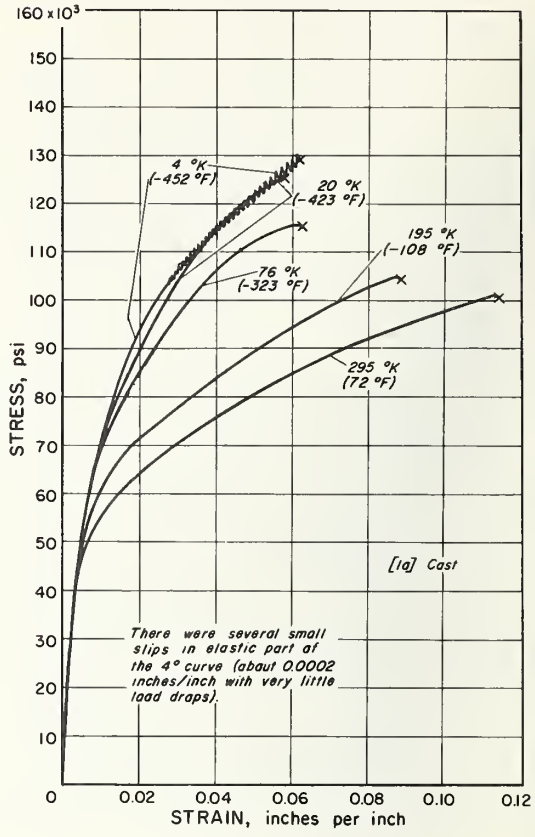
Tensile Reduction of Area of Cu-Al-Ni (Nickel Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Sand cast - 0.025mm. G.S. - R_B = 93, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute.	Bal			10.0	5.2	3.4Fe, 0.3Mn	1
75a	Annealed at 900°C - quenched. Bar sample - 0.25 inch diam	92.3			1.7	5.9		75
75b	Annealed at 900°C - quenched - reheated at 550°C - 2 hrs. Bar sample - 0.25 inch diam.	92.3			1.7	5.9		75
91	Annealed 850°C - 1/2 hr. - air cooled - after cold drawing.	Bal			10.2	4.7	4.1Fe, 0.1Mn	91
92	Annealed 850°C - 1/2 hr. - air cooled - after cold drawing.	Bal			10.5	4.8	3.6Fe	92
316a	Sand cast (double keel blocks) - R_B = 96. Machined sample.	79.7			11.5	4.5	4.3Fe, 0.1Si	316
316b	Annealed bar - R_B = 104.	Bal			9.7	4.8	2.6Fe, 0.1Mn	316
316c	Hot rolled, sheet supplied.	82.3			9.4	5.0	2.4Fe, 0.9Mn	316
316d	Annealed - R_B = 95 - after extruding and cold drawing.	81.2	0.1		10.1	4.8	3.0Fe, 0.8Mn	316



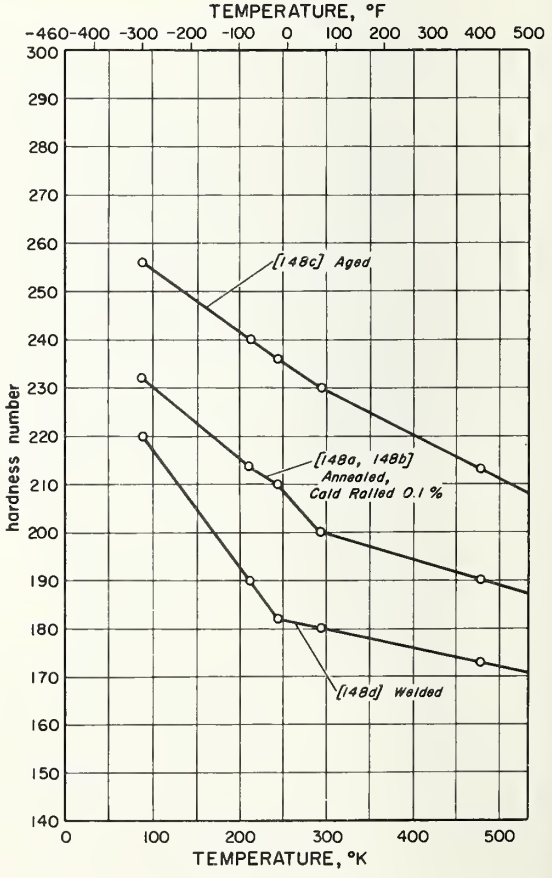
Tensile Stress-Strain Curves of Cu-Al-Ni (Nickel Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
1a	Sand cast - 0.036mm. G.S. - R_B = 93, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.247 inch reduced diam., crosshead speed = 0.02 inch/minute, clamp-on strain gage extensometer, 1 inch G.L.	Bal			10.0	5.2	3.4Fe, 0.3Mn	1



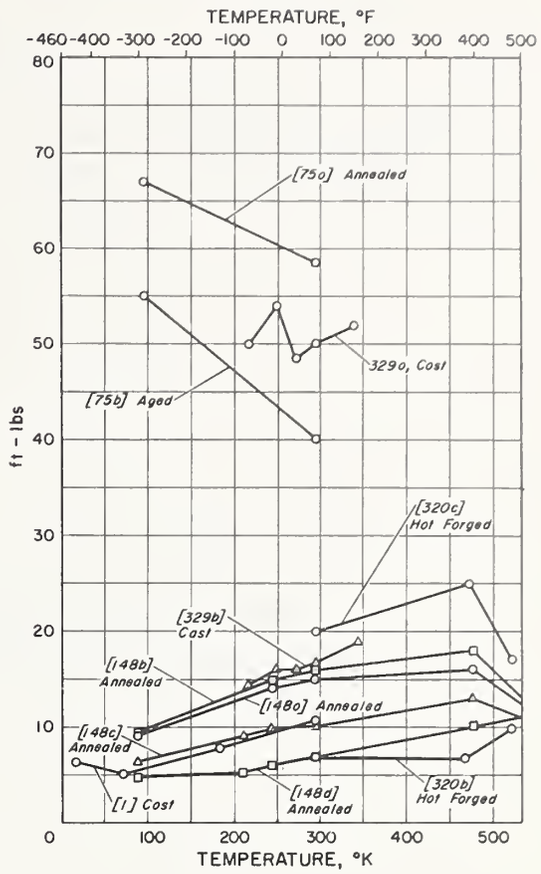
Hardness of Cu-Al-Ni (Nickel Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Aℓ	Ni	Other	
148a	Annealed 1150°F - "quickly" cooled, grade 45. Bar sample - reduced section: 2 inches long X 0.505 inch diam. - polished with 00 emery cloth, Brinell hardness - 10mm Carboloy ball - 3000 Kgm. load.	81.2	0.1		10.1	4.8	3.0Fe, 0.8Mn	148
148b	Cold rolled 0.1% - after first annealing 1150°F - then cold drawing 3% - then re-annealing 1150°F and "quickly" cooling. Other specifications same as 148a.	81.2	0.1		10.1	4.8	3.0Fe, 0.8Mn	148
148c	Heated 1650°F - water quenched - then aged at 1200°F - air cooled. Other specifications same as 148a.	81.2	0.1		10.1	4.8	3.0Fe, 0.8Mn	148
148d	Carbon arc welded, nominal weld composition listed. Other specifications same as 148a.	82.4			8.8	4.6	3.0Fe, 0.8Mn, 0.5Si	148



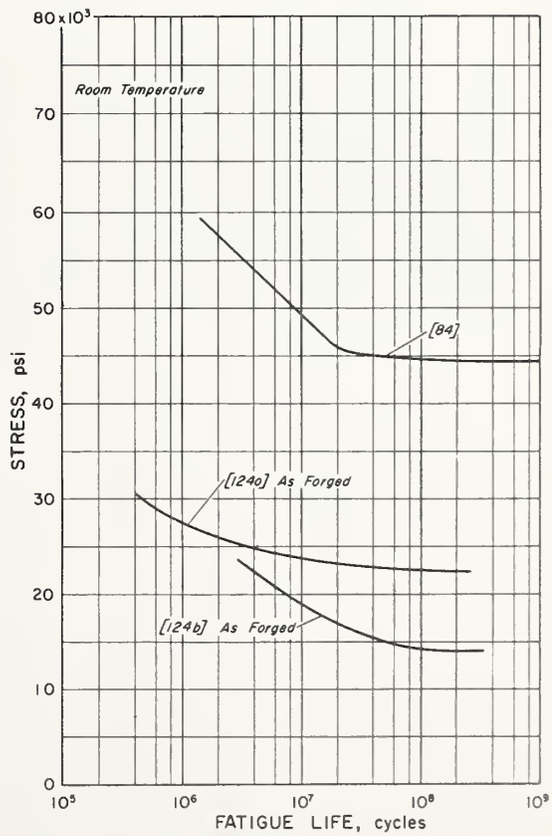
Impact Energy of Cu-Al-Ni (Nickel Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
1	Sand cast - 0.036mm. G.S. - R_B = 93. Charpy V-notch, samples fractured completely, sample contained in paper boat for -423°F tests.	Bal			10.0	5.2	3.4Fe, 0.3Mn	1
75a	Annealed at 900°C - quenched. Izod.	92.3			1.7	5.9		75
75b	Annealed at 900°C - quenched - then reheated 2 hrs. at 550°C. Izod.	92.3			1.7	5.9		75
148a	Annealed 1150°F - "quickly" cooled, grade 45. Izod sample, 3 tests/temp.	81.2	0.1		10.1	4.8	3.0Fe, 0.8Mn	148
148b	Cold rolled 0.1% - after first annealing 1150°F - then cold drawing 3% - then re-annealing 1150°F - and "quickly" cooling, grade 45. Izod sample, 3 tests/temp.	81.2	0.1		10.1	4.8	3.0Fe, 0.8Mn	148
148c	Heated 1650°F - water quenched - then aged at 1200°F - air cooled, grade 45. Izod sample, 3 tests/temp.	81.2	0.1		10.1	4.8	3.0Fe, 0.8Mn	148
148d	Carbon arc welded, nominal weld composition listed, grade 45. Izod sample, 3 tests/temp.	82.4			8.8	4.6	3.0Fe, 0.8Mn, 0.5Si	148
320b	Hot forged. Izod, held 30 minutes at temp. prior to test.	88.2			9.9	1.5	0.3Fe	320
320c	Hot forged. Izod, held 30 minutes at temp. prior to test.	87.7			9.3	2.0	1.0Fe	320
329a	Gravity die cast. Unnotched sample - 2.36 inches × 1/4 inch × 1/4 inch.	80.2			9.5	5.0	5.2Fe	329
329b	Gravity die cast. Notched specimen = 60 × 10 × 10mm. - V notch: 2mm. deep with 0.25mm. root radius.	80.2			9.5	5.0	5.2Fe	329



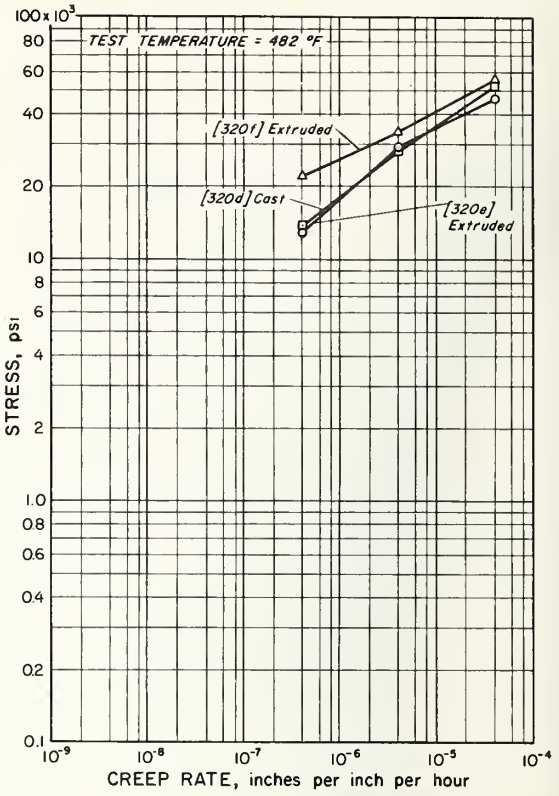
Fatigue Behavior of Cu-Al-Ni (Nickel Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF. NO.
		Cu	Zn	Sn	Al	Ni	Other	
84	Smooth samples, rotating beam (R. R. Moore) - 12,000 r.p.m.	81.8			9.9	4.7	2.9Fe, 0.7Mn	84
124a	As forged, room temp.: U.T.S. = 116,000 psi - Y.S. = 73,500 psi (0.1% offset) - Brinell hardness = 226. Bar sample - 0.275 inch diam., rotating beam - 2200 c.p.m.	79.8			9.7	5.0	5.4Fe	124
124b	3% salt in H_2O atmosphere produced by spraying sample during test. Other specifications same as 124a.	79.0			9.7	5.0	5.4Fe	124



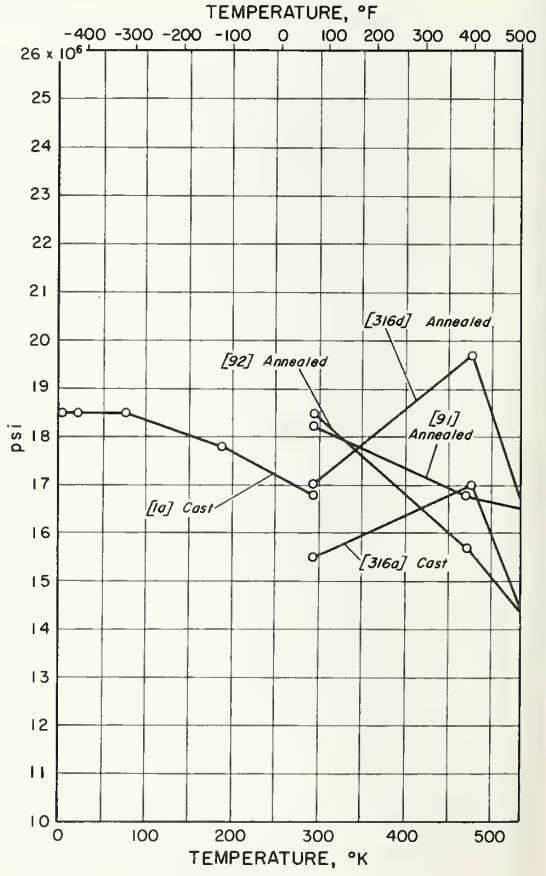
Creep Behavior of Cu-Al-Ni (Nickel Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
320d	Sand cast. Sample - 5 inches long X 0.1 square inch reduced section, ± 0.0001 inch extensometer sensitivity, constant load, data obtained after 5 days under load.	80.5			9.5	4.8	5.4Fe	320
320e	Extruded. Other specifications same as 320d.	80.4			9.9	4.9	5.0Fe	320
320f	Data obtained after 40 days under load. Other specifications same as 320e.	80.4			9.9	4.9	5.0Fe	320



Modulus of Elasticity of Cu-Al-Ni (Nickel Aluminum Bronze)

CURVE NO.	MATERIAL AND TEST PARAMETERS	COMPOSITION (weight%)						REF NO.
		Cu	Zn	Sn	Al	Ni	Other	
1a	Sand cast - 0.036mm. G.S. - R_B = 93, bar supplied - 3/4 inch diam. Bar sample - reduced section: 1.5 inches long X 0.250 inch diam., Young's modulus derived from stress vs. strain curves, 1 inch G.L.	Bal			10.0	5.2	3.4Fe, 0.3Mn	1
91	Annealed 850°C - 1/2 hr. - air cooled - after cold drawing.	Bal			10.2	4.7	4.1Fe, 0.1Mn	91
92	Annealed 850°C - 1/2 hr. - air cooled - after cold drawing.	Bal			10.5	4.8	3.6Fe	92
316a	Sand cast (double keel blocks) - R_B = 96. Machined sample.	79.7			11.5	4.5	4.3Fe, 0.1Si	316
316d	Annealed bar - R_B = 95.	Bal	0.1		10.1	4.8	3.0Fe, 0.8Mn	316



Section III

Classification, using tables, of reliable investigations which could not be included in Section II because of its format.

Contents

1. Reference Guide for Review Papers

Subject	*References*
Including most copper alloys	51, 52, 63, 68, 103, 111, 117, 144, 189, 199, 218, 225, 239, 251, 265, 280, 287, 295, 298, 308, 309, 310, 316, 317, 318, 321–324, 330, 337, 339, 345, 411, 419, 426, 437.
Including only copper	2, 274, 429
Including only one specific property	18, 67, 83, 91, 121, 130, 259, 427

2. Reference Guide for Experimental Papers—Copper

ALLOY	TYPE OF TEST	TEMPERATURES OF TEST			EXPERIMENTAL VARIABLES, EFFECT OF						SINGLE CRYSTALS USED
		Ambient	High	Low	Cold Work	Irradiation	Heating, Annealing	Testing Parameters	Chemistry, Atmosphere, Surface	Flow Stress Measured	
Copper	Tensile										
High purity		3, 34, 35, 157, 200, 237, 275, 325, 408, 431	196, 409	35, 48, 196, 227, 333, 360, 361	237, 275, 325	34, 361	408	157, 196, 360	3	35, 48, 200, 227, 361, 409	3, 34, 35, 48, 196, 227, 275 325, 361, 431
OFHC		8, 15, 151, 208, 219, 221, 370	8, 203, 205, 344	203, 207	8, 151 221		8	8, 205, 207, 208, 344	8	205	
Variety		290	368		368		290		290, 368		
Not Reported		19, 37, 53, 100, 147, 177, 185, 193, 194, 255, 278, 284, 297, 304, 315, 319, 349, 372, 380, 382, 385, 388, 396, 398, 410, 413, 444, 446, 458, 461	50, 256, 354, 391, 415, 463	50, 288, 354	53, 100, 185, 255, 304, 349, 380, 388	349, 382, 388, 396	185, 278	37, 185, 193, 194, 255, 256, 284, 297, 315, 319, 372, 391, 446, 458	256, 385, 413	50, 354	37, 177, 354, 388, 398, 410, 446
	Compression										
OFHC		8	8								
Not Reported		5, 70, 257	5	5, 142			70	5			
	Torsion										
High purity		34, 36, 116, 138, 197, 276		140	140	34, 140, 197	36, 197		276	36	34, 36, 116, 138, 197, 276
OFHC		15, 450									
Not Reported		396				396					
	Impact	248						248			
	Hardness										
High purity		407									
OFHC		8, 25, 70, 237, 382, 418	8, 432		8, 237	25, 382	8, 70				
Not Reported		393, 396	415			393, 396					

3. Reference Guide for Experimental Papers—Copper

ALLOY	TYPE OF TEST	TEMPERATURES OF TEST			EXPERIMENTAL VARIABLES, EFFECT OF						SINGLE CRYSTALS USED
		Ambient	High	Low	Cold Work	Irradiation	Heating Annealing	Testing Parameters	Chemistry, Atmosphere, Surface	Flow Stress Measured	
Copper (cont.) High purity	Fatigue	325						325			325
OFHC		8, 62, 74, 135, 219, 220, 326, 342, 453	2, 8, 344		8, 135		8	2	62, 326		
Not Reported		30, 65, 97, 114, 136, 160, 331, 414, 428, 434, 435, 462			30, 160			30, 65, 428, 434			136, 414, 434, 435
OFHC	Creep	14, 245, 340	8, 23, 110, 151, 205, 344, 443		14, 151, 245	340					450
Variety		290, 307, 390					290, 307	390	290, 307		
Not Reported		31, 305, 346	31, 32 154, 161, 224, 313, 389, 416, 440		346			154, 161, 245	32, 305		224
High purity	Elastic Modulus	99, 167, 168, 244, 402	139	47, 96, 158, 159, 167, 168, 244, 312 364, 448	96	47, 158, 159, 167, 168, 312 448	448		99		244, 312, 364, 402
OFHC		76, 221, 293			76, 221, 293		293				
Not Reported		181, 186, 243, 268, 299, 315, 348, 375, 392, 406			181, 186, 243, 348, 406	392	181, 186, 299, 375	268	315		
Not Reported	Shear Modulus		262	94	94						

4. Reference Guide for Experimental Papers—Brass

ALLOY	TYPE OF TEST	TEMPERATURES OF TEST			EXPERIMENTAL VARIABLES, EFFECT OF						SINGLE CRYSTALS USED
		Ambient	High	Low	Cold Work	Irradiation	Heating Annealing	Testing Parameters	Chemistry, Atmosphere, Surface	Flow Stress Measured	
Brass (Cu-Zn)	Tensile										
Cu-Zn		102, 166, 201, 417	415	107, 227	102, 166, 417		102, 417		107, 166, 201, 227	227	227
Cu-20Zn		240			240			240			
Cu-30Zn		157, 219, 277, 284, 296, 369, 374	137	240			374	157, 277, 284, 296	137, 277, 369		
Cu-35Zn		404, 464	105		464		464	404	404		
Cu-35Zn-3Pb		400									
Cu-41Zn-2Pb		334, 458						334, 458			
Cu-49Zn				335							
Cu-Zn	Torsion	102		102, 140			102		140		
Cu-30Zn		69						69			
Cu-35Zn		464			464		464				
Cu-Zn	Impact	102			102		102				
Cu-35Zn-3Pb		248						248			
Cu-Zn	Hardness	98, 102	240, 415		102		102		98		
Cu-30Zn		17	137		17		17		137		
Cu-35Zn		464			464		464				
Cu-Zn	Fatigue	166, 178, 220, 417	336		166, 417		417	178	166, 220, 336		
Cu-30Zn		42, 123, 219, 342	39, 41, 42, 344	39			41, 42		123		
Cu-40Zn		306									
Cu-Zn	Creep		109	107					107, 109		
Cu-30Zn		277	41, 344				41		277		
Cu-35Zn			105	106							
Cu-30Zn	Elastic Modulus	76			76						
Cu-35Zn		383, 412			383, 412		383, 412				
Cu-Zn	Shear Modulus	183, 184			183, 184		183		183, 184		

5. Reference Guide for Experimental Papers — Phosphor Bronze, Aluminum Bronze, Copper-Nickel

ALLOY	TYPE OF TEST	TEMPERATURES OF TEST			EXPERIMENTAL VARIABLES, EFFECT OF						SINGLE CRYSTALS USED
		Ambient	High	Low	Cold Work	Irradiation	Heating Annealing	Testing Parameters	Chemistry, Atmosphere, Surface	Flow Stress Measured	
Phosphor Bronze	Tensile										
Cu-Sn		405						405	405		
Cu, 3-8Sn		80			80				80		
Cu-5Sn		44, 80	44	44			44				
Cu, 3-8Sn	Hardness	80			80				80		
Cu-8Sn	Fatigue	122						122			
Cu-Sn	Elastic Modulus		162	162							
Cu-4.5Sn		43	43								
Cu-4.5Sn	Shear Modulus	43	43								
Aluminum Bronze	Tensile										
Cu-Al		13, 169, 219, 358, 381, 397	267	267 332		397	169, 267	13, 381	13, 267, 332, 358, 381		169, 397
Cu-Al	Hardness	13, 98	267	267			267	13	13, 98, 267		
Cu-Al	Fatigue	219, 246	222, 235		222		222, 235	246	235		
Cu-Al	Creep		222, 250		222		222				
Cu-6Al			90, 377, 378.				90, 377, 378				
Copper-Nickel	Tensile										
Cu-Ni		358							358		
Cu-20Ni	Fatigue	123							123		
Cu-Ni	Creep	390	250						250		
Cu-Ni	Elastic Modulus	303, 447							303, 447		447
Cu-40Ni			352								

6. Reference Guide for Experimental Papers—Other Alloys

ALLOY	TYPE OF TEST	TEMPERATURES OF TEST			EXPERIMENTAL VARIABLES, EFFECT OF						SINGLE CRYSTALS USED
		Ambient	High	Low	Cold Work	Irradiation	Heating Annealing	Testing Parameters	Chemistry, Atmosphere, Surface	Flow Stress Measured	
Other Alloys	Tensile										
Cu,Be,Cr		401			401		401				
Cu, Be, Co		26, 277, 297		26, 269	269		269	297	277		
Cu, Ge				132				132	132		132
Cu, Ga				132				132	132		132
Cu, Zn, Fe, Si		26		26							
Cu, 5-30 Ni, 30-55 Zn		77					77		77		
Cu-23Zn-4Al-3Fe		81						81	81		
Cu-24Zn-6Al-4Mn-3Fe		93					93		93		
Cu, Zr		373, 399									
Cu, Be	Impact			269	269		269		269		
Cu, Be	Hardness	46		46							
Cu,Be,Cr		401			401		401				
Cu, 5-30 Ni, 30-55 Zn		77					77		77		
Cu-3Ni 1Si		451					451				
Cu-23Zn-4Al-3Fe	Fatigue	81						81	81		
Cu-26Zn-18Ni		122						122			
Cu-2Be			341	341							
	Creep	277							277		
Cu, Ni, Zn	Elastic Modulus	127							127		
Cu, 45-50Zn				223					223		
Cu, Be	Shear Modulus		262								

7. Reference Guide for Experimental Papers—Many Alloys in One Investigation

ALLOY	TYPE OF TEST	TEMPERATURE OF TEST			EXPERIMENTAL VARIABLES, EFFECT OF						SINGLE CRYSTALS USED
		Ambient	High	Low	Cold Work	Irradiation	Heating Annealing	Testing Parameters	Chemistry, Atmosphere, Surface	Flow Stress Measured	
Many Cu Alloys	Tensile	49, 86, 112, 294, 384, 430	82, 155	155			49, 294, 430		112, 294, 384		
	Compression	394	155	155							
	Impact		155	155							
	Fatigue	86, 206	155					206			
	Creep		73, 228					228	73		
	Elastic Modulus	238, 303	175						175, 238, 303		

Section IV

List of References

List of References

1. NBS Institute for Materials Research, Cryogenics Division, Boulder, Colo., Experimental data obtained on contract for International Copper Research Association and Copper Development Association (1965).
2. *Achter, M. R.*, Mechanical behavior of metals in vacuum (Inst. Environmental Sci. Proc., 1963), p. 385.
3. *Achter, M. R., Danek, Jr., G. J., Smith, H. H.*, Effect on fatigue of gaseous environments under varying temperature and pressure, Trans. AIME **227,** 1296 (1963).
4. *Adams, M. A.*, The plastic behavior of copper crystals containing zinc in the surface layer, Acta Met. **6,** 327 (1958).
   Adams, M. A., Higgins, P. R. B., The hardening of copper by neutron irradiation, Phil. Mag. **4,** 777 (1959)—[Ref. 433].
5. *Alder, J. F., Phillips, V. A.*, The effect of strain rate and temperature on the resistance of aluminum, copper, and steel to compression, J. Inst. Metals **83,** 80 (1955).
6. *Alers, G. A., Thompson, D. O.*, Dislocation contributions to the modulus and damping in copper at megacycle frequencies, J. Appl. Phys. **32,** 283 (1961).
   Alers, G. A., Zimmerman, J. E., Dislocation mobility in fcc metals below 1 °K, Phys. Rev. **139,** A414 (1965)—[Ref. 364].
7. *Allen, N. P.*, Recent European work on the mechanical properties of metals at low temperatures, NBS Circ. 520 (1952), p. 1.
8. *American Metal Co., Ltd.*, OFHC Brand Copper (American Metal Co., Ltd., New York, 1957).
9. *Am. Soc. Mech. Engr.*, Am. Soc. Testing Mat., Compilation of Available High Temperature Creep Characteristics of Metals and Alloys (1938).
   Amfiteatrova, T. A., Yampdol'sky, B. Ya., Deformation of metals at low stresses. II—Influence of adsorption-active media on creep of copper and aluminum, Phys. Metals Metallog. **7,** #5, 130 (1959)—[Ref. 413].
10. *Anderson, A. R., Swan, E. F., Palmer, E. W.*, Fatigue tests on some copper alloys, Proc. ASTM **46,** 678 (1946).
11. *Anderson, A. R., Smith, C. S.*, Fatigue tests on some copper alloys, Proc. ASTM **41,** 849 (1941).
12. *Argent, B. B.*, The tensile properties of the alpha brasses, J. Inst. Met. **93,** 460 (1965).
13. *Awada, M. Iwano, N., Tanisawa, H., Yosida, S., Yamagata, K.*, Mechanical properties of castings of aluminum bronzes, S. Japan Foundrymen's Soc., Imono, **32,** 948 (1960).
14. *Azhazha, V. M., Gindin, I. A. Starodubov, Ya. D., Shapoval, B. I.*, Influence of deformation at low temperatures on creep and internal friction of copper, Fiz. Metal. Metallov. **15,** 729 (1963).
15. *Backofen, W. A., Shaler, A. J., Hundy, B. B.*, Mechanical anisotropy in copper, Trans. ASM **46,** 655 (1954).
16. *Bailey, A. R.*, The fracture characteristics of brass in impact at atmospheric and elevated temperatures, J. Inst. Metals **89,** 339 (1961).
17. *Baird, C., Jennings, P. H.*, The effect of low-temperature annealing on the indentation hardness of cold-worked alpha-brass, J. Inst. Metals **89,** 191 (1960–61).
18. *Baker, W. A.*, Creep of non-ferrous metals and alloys, A review of published information, Brit. Non-Ferrous Met. Res. Assoc. Rept. #449, (1937).
19. *Balasse, G., Gaspard, R.*, Tensile-test curves for copper (wire) under constantly increasing load, Compt. Rend. **245,** 497 (1957).
20. *Barnby, J. T.*, The spacing of slip lines in metals, ASTIA (Nov. 1961).
21. *Baron, H. G.*, Effect of strain rate on the tensile stress-strain characteristics of metals, Metal Treat. **29,** 25 (1962).
22. *Baron, H. G.*, Stress-strain curves of some metals and alloys, J. Iron Steel Inst. **182,** 354 (1956).
   Baron, V. V., Savitskii, E. M., The effect of temperature on the strength of brittle metallic substances, Dokl. Acad. Nauk. (SSSR) **94,** 269 (1954)—[Ref. 403].
23. *Barrett, C. R., Sherby, O. D.*, Influence of stacking-fault energy on high-temperature creep of pure metals, Trans. AIME **233,** 1116 (1965).
   Barrett, C. R., Sherby, O. D., Steady-state creep characteristics of polycrystalline copper in the temperature range 400° to 950 °C, Trans. AIME **230,** 1322 (1964)—[Ref. 443].
24. *Bassett, W. H.*, Discussion on properties of copper and its alloys, Symposium on Effect of Temperature on the Properties of Metals (ASTM and ASME, Philadelphia, Pa. 1931), p. 351.
25. *Beevers, C. J., Barnes, R. S.*, The microhardness of copper bombarded with alpha particles, J. Inst. Metals **89,** 125 (1960).
26. *Belton, J. H., Godby, L. L., Taft, B. L.*, Materials for use at liquid hydrogen temperatures, ASTM Spec. Tech. Publ. 287, 108 (1961).
   Bendler, H. M., Nine, H. D., Fatigue failure in copper single crystals at low and high amplitudes of torsion, Nature **194,** 1069 (1962)—[Ref. 434].
27. *Bengough, G. D., Hanson, D.*, The tensile properties of copper at high temperatures, J. Inst. Metals **12,** 56 (1914).
28. *Bengough, G. D.*, A study of properties of alloys at high temperatures, J. Inst. Metals **7,** 123 (1912).
29. *Benham, P. P.*, Axial-load and strain cycling fatigue of copper at low endurance, J. Inst. Metals **89,** 328 (1961).
30. *Benham, P. P.*, Torsional-strain-cycling fatigue of copper at low endurance, J. Inst. Metals **91,** 404 (1963).
   Benson, N. D., McKeown, J., Mends, D. N., The creep and softening properties of copper for alternator rotor windings, J. Inst. Metals **80,** 131 (1951)—[Ref. 376].
   Beresnev, B. I., Balychev, D. K., Mechanical properties of Al and Cu after high-pressure extruding, Fiz. Metal Metallov. (USSR) **16,** 117 (1963)—[Ref. 380].
31. *Bhattacharya, S., Congreve, W. K. A., Thompson, F. C.*, The creep-time relationship under constant tensile stress, J. Inst. Metals **81,** 83 (1952).
   Blank, A. I., Burghoff, H. L., Creep characteristics of phosphorized copper (0.019 percent *P*) at 300, 400, and 500F, Proc. ASTM **51,** 981 (1951)—[Ref. 362].
   Blatherwick, A. A., Mowbray, D. F., Stress-strain relationships in low-and-intermediate-cycle fatigue, Proc. ASTM **64,** 561 (1964)—[Ref. 428].
32. *Bleakney, H. H.*, The ductility of metals in creep-rupture tests, Canadian J. Technology **30,** 340 (1952).
   Blewitt, T. H., Low temperature irradiation studies, Proc. Intn. School Physics, E. Fermi Course XVIII (*Radiation Damage in Solids*, Academic Press, New York, 1962), p. 630—[Ref. 395].
33. *Blewitt, T. H. Coltman, R. R., Redman, J. K.*, Low temperature deformation of Cu single crystals, J. Appl. Phys. **28,** 651 (1957).
34. *Blewitt, T. H., Coltman, R. R., Jamison, R. E., Redman, J. K.*, Radiation hardening of copper single crystals, J. Nuclear Materials **2,** 277 (1960).
35. *Blewitt, T. H.*, Deformation of copper single crystals at 300 degrees K and 78 degrees K, Phys. Rev. **91,** 1115 (1953).
36. *Blewitt, T. H., Coltman, R. R., Redman, J. K.*, Work hardening in copper crystals, Proc. Phys. Soc. (London) **B67,** 369 (1954).
37. *Bokshtein, S. Z., Kishkin, S. T., Svetlov, I. L.*, Tensile testing of filament crystals of copper, nickel and cobalt to failure, Soviet Phys. Solid State **4,** No. 7, 1272 (1963).
38. *Bolton, J. W., Hehemann, F. H.*, Discussion on properties of copper and its alloys, Symposium on Effect of Temperature on the Properties of Metals (ASTM and ASME, Philadelphia, Pa., 1931), p. 361.
39. *Boone, W. D., Wishart, H. B.*, High-speed fatigue tests of several ferrous and nonferrous metals at low temperatures, Proc. ASTM **35,** 147 (1935).
40. *Bordoni, P. G.*, Elastic and anelastic behavior of some metals at very low temperatures, J. Acoust. Soc. Am. **26,** 495 (1954).
   Bovet, H., Zirconium alloyed copper, Pro-Metal **13,** 375 (1960)—[Ref. 399].
   Bregowsky, I. M., Spring, L. W., The effect of high temperatures on the physical properties of some alloys (Proc. (Pt. II) Intn. Assoc. Testing Mat., 6th Congr., New York, 1912), Section VII—[Ref. 449].
41. *Breen, J. E., Lane, J. R.*, Effect of dispersion of alpha brass on the high temperature fatigue properties of alpha-beta brass, Trans. ASM **49,** 959 (1957).
42. *Breen, J. E., Lane, J. R.*, Effect of grain size on high temperature fatigue properties, Trans. ASM **46,** 1021 (1954).
43. *Brombacher, W. G.*, Temperature coefficient of the elastic moduli of spring materials used in instrument design, Rev. Sci. Inst. **4,** 688 (1933).
44. *Broniewski, W., Szreniawski, J.*, L'influence de la température et de l'ecrouissage sur les propriétes mecaniques d'um bronze pous medailles, Rev. Metall. **33,** 442 (1936).
45. *Broniewski, W., Wesolowski, K.*, L'influence de la temperature sur les properties mechaniques de laitons, Rev. Metall. **30,** 396, 453 (1933).
46. *Brooks, H. E., Johnston, H. L.*, Hardness of various metals at low temperatures down to 20° absolute, ASTIA Rept. 161564 (1952).
47. *Bruner, L. J., Mecs, B. M.*, Modulus and damping of copper after plastic deformation at 4.2 degrees K. Phys. Rev. **129,** 1525 (1963).
48. *Buck, O.*, Deformation and electrieal resistance of copper single crystals at very low temperatures, Phys. Stat. Solidi **2,** 535 (1962).
49. *Buell, M. A.*, Grain size is important, Prod. Engr. **33,** 46 (1962).
50. *Bullen, F. P., Hutchison, M. M.*, The temperature-dependence of strain-hardening in polycrystalline copper, Phil. Mag. **8,** 461 (1963).
51. *Bulow, C. L.*, Copper and its alloys for low temperature versatility, Chem. Eng. **67,** 187 (1960).
52. *Bulow, C. L.*, Properties of copper alloys at cryogenic temperatures, Engr. Design News **9,** 70 (1964).
53. *Bulychev., D. K., Beresnev, B. I., Gaydukov, M. G., Martynov, E. D., Rudionov, E. D., Ryabinin, Yu. N.*, Structural defects and plastic deformation of copper at high pressures, Dokl. Acad. Nauk. (SSSR) **156,** 67 (1964).

54. *Bunting, D.*, The brittle range in brass shown by the Izod impact test, J. Inst. Metals **31,** 47 (1924).
55. *Burghoff, H. L., Blank, A. I.*, Fatigue tests on some copper alloys in wire form, Proc. ASTM **43,** 774 (1943).
56. *Burghoff, H. L., Blank, A. I.*, Fatigue characteristics of some copper alloys, Proc. ASTM **47,** 695 (1947).
57. *Burghoff, H. L., Blank, A. I.*, Creep characteristics of a phosphorized copper, Trans. AIME **161,** 420 (1945).
58. *Burghoff, H. L., Blank, A. I.*, Fatigue properties of some copper and copper alloys in strip form, Proc. ASTM **48,** 709 (1948).
59. *Burghoff, H. L.*, Strength of copper at elevated temperatures, Electrical Mfg. **52,** 143 (1953).
60. *Burghoff, H. L., Blank, A. I.*, The creep characteristics of copper and some copper alloys at 300, 400 and 500 °F, Proc. ASTM **47,** 725 (1947).
61. *Burghoff, H. L., Blank, A. I., Maddigan, S. E.*, The creep characteristics of some copper alloys at elevated temperatures, Proc. ASTM **42,** 668 (1942).
62. *Burmeister, R. A., Dodd, R. A.*, The effect of electrodeposited metals on fatigue life, Proc. ASTM **62,** 675 (1962).
63. *Butts, A.*, Copper, The Metal, Its Alloys and Compounds (Reinhold Publ. Corp., New York, 1964).
Bystrov, L. N., Ivanov, L. I., Prokoshkin, D. A., Creep of copper and copper-nickel alloys during torsion, Izvest. Akad. Nauk. (SSSR), Met. i Topl. No. 5, 197 (1962)—[Ref. 390].
64. *Camenisch, K. P.*, Comportement du cuivre et de ses alliages á hautes et basses temperatures, Pro-Metal **85,** 611 (1962).
65. *Campion, D. J.*, Fatigue tests at large strains on copper wires, War Office, Armament Res, & Dev. Est. Materials Explosives Div., ARDE Memo (MX) 83/60 (1960).
66. *Carreker, R. P., Jr., Hibbard, Jr., W. R.*, Tensile deformation of high-purity copper as a function of temperature, strain rate, and grain size, Acta Met. **1,** 654 (1953).
67. *Cazaud, R.*, Fatigue of Metals, (Philosophical Library, New York, 1953).
68. *Chalmers, B.*, Progress in Materials Science **9** (Pergamon Press, Inc., New York, 1961), p. 389.
69. *Chang, S. S., Heginbotham, W. B.*, Comparisons between the shearing properties of alpha-brass as derived from the cutting process and from static and impact torsion tests, J. Engr. Industry **82,** 315 (1960).
70. *Clarebrough, L. M., Hargreaves, M. E., Loretto, M. H.*, The influence of grain size on the stored energy and mechanical properties of copper, Acta Met. **6,** 725 (1958).
71. *Clark, C. L., White, A. E.*, Influence of recrystallization temperature and grain size on the creep characteristics of non-ferrous alloys, Proc. ASTM **32,** 492 (1932).
72. *Clark, C. L., White, A. E.*, Properties of non-ferrous alloys at elevated temperatures, Metal Ind. (London) **37,** 601 (1930).
73. *Clark, C. L., White, A. E.*, Properties of non-ferrous alloys at elevated temperatures, Trans. ASME **53,** 183 (1931).
74. *Coffin, L. F., Jr., Tavernelli, J. F.*, The cyclic straining and fatigue of metals, Trans. AIME **215,** 794 (1959).
Coffin, L. F., Low Cycle Fatigue, ASM Metals Engr. Quart. **56,** 15 (1963)—[Ref. 453].
75. *Colbeck, E. W., MacGillivray, W. E.*, The mechanical properties of metals at low temperatures. Part II—Non-ferrous materials, Trans. Inst. Chem. Engrs. **11,** 107 (1933).
76. *Cook, M., Richards, T. L., Bidmead, G. F.*, Influence of cold deformation on the Young's modulus of some non-ferrous metals, J. Inst. Metals **83,** 41 (1954).
77. *Cook, M.*, The physical and mechanical properties of nickel brasses, J. Inst. Metals **42,** 139 (1938).
78. *Cook, M., Lark, E. C.*, Copper and copper alloys for locomotive firebox construction, J. Inst. Loco. Engr. **28,** 609 (1938).
79. *Cook, M., Lark, E. C.*, Impact strength of copper, J. Inst. Metals **58,** 1 (1942).
80. *Cook, M., Tallis, W. G.*, The physical properties and annealing characteristics of standard phosphor-bronze alloys, J. Inst. Metals **67,** 49 (1941).
81. *Crossley, F. A., Simcoe, C. R.*, A study of stress-induced delayed failure in high-strength brasses, Armour Res. Found., Ill. Inst. Tech, ASTIA Rept. 258399 (1960).
82. *Crowe, C. H.*, Properties of some copper alloys at elevated temperatures, ASTM Bull. **250,** 30 (1960).
83. *Crussard, C., Plateau, J., Tamhankar, R., Henry, G., Lajeunesse, D.*, A comparison of ductile and fatigue fractures, Fracture (J. Wiley & Sons, New York, 1959), p. 524.
84. *Cummings, H. N., Stulen, F. B., Schulte, W. C.*, Investigation of material fatigue problems, Curtiss Wright Corp., ASTIA Rept. 134539 (1957).
85. *Cupp, C. R., Chalmers, B.*, A study of the plastic deformation of copper single crystals, Acta Met. **2,** 803 (1954).
86. *Cuthbertson, J. W.*, Fatigue properties of brasses, bronzes and bearing metals, Metal Treat. **24,** 89 (1957).
87. *Cuykendall, T. R., Sack, H. S.*, Dynamic elastic properties of solids Cornell Univ., Clearinghouse, Fed. Sci. Tech. Info., Rept. PB-121701 (1955).
Davenport, C. C., Correlation of creep and relaxation properties of copper, Trans. ASME **60,** A-55 (1938) —[Ref. 416].
88. *Davis, E. A.*, Creep and relaxation of oxygen-free copper, Trans. ASME **10,** A101 (1943).
89. *DeHaas, W. J., Hadfield, R.*, On the effect of temperature of liquid hydrogen on the tensile properties of forty-one specimens of metals comprising (a) pure iron 99.85%; (b) four carbon steels; (c) thirty alloy steels; (d) copper and nickel; (e) four non-ferrous alloys, Trans. Roy. Soc. (London) **232A,** 297 (1933).
90. *Dennison, J. P.*, The effect of heat treatment on the creep and creep-rupture behavior of a high purity alpha copper-aluminum alloy at 300° and 500 °C, J. Inst. Metals **86,** 177 (1958).
Dennison, J. P., Some creep characteristics of a group of precipitation hardening alloys based on the alpha copper-aluminum phase, J. Inst. Metals **82,** 117 (1953-54)—[Ref. 377].
Dennison, J. P., Creep behavior at 300 °C of a group of precipitation-hardening alloys based on the alpha copper-aluminum phase, J. Inst. Metals **83,** 465 (1954-55)—[Ref. 378].
Diehl, J., Influence of neutron irradiation on the mechanical properties of face-centered cubic crystals, Radiation Damage in Solids (Intn. Publ. Inc., New York, 1962), p. 129—[Ref. 382].
Diehl, J., Berner, R., Temperaturabhangigkeit der Verfestigung von Kupfer-Einkristallen oberhalb 78 °K, Z. Metallk. **51,** 522 (1960)—[Ref. 354].
91. *Dies, K., Jung-Konig, W.*, The creep behavior of some technical copper alloys at high temperatures, Metall. **16,** 1097 (1962).
92. *Dies, K., Jung-Konig, W.*, Contributions to the problems of creep behavior of copper alloys, Metall. **14,** 1085 (1960).
93. *Domagala, R. F.*, A study of high tensile brasses, Armour Res. Found., ASTIA Rept. AD162371 (1958).
Donachie, M. J., Steele, R. K., Shepheard, P. G., Elevated-temperature behavior of annealed 70–30 copper-nickel, Proc. ASTM **63,** 598 (1963)—[Ref. 425].
94. *Druyvesteyn, M. J., Schannen, O. F. Z., Swaving, E. C.-J.*, Influence of cold work on the rigidity of copper, Physica **25,** 1271 (1959).
95. *Druyvesteyn, M. J.*, Experiments on the effect of low temperature on some plastic properties of metals, Appl. Sci. Res. **AI,** 66 (1947).
96. *Druyvesteyn, W. F., Blaisse, B. S.*, Change in the modulus of elasticity of copper after deformation in the temperature range from 4.2–7.8 °K, Physica **28,** 695 (1962).
97. *Ebner, M. L., Backofen, W. A.*, Fatigue and anisotropy in copper, Trans. ASM **48,** 872 (1956).
98. *Edwards, C. A., Herbert, A. M.*, Plastic deformation of some copper alloys at elevated temperatures, J. Inst. Metals **25,** 175 (1921).
99. *Eisner, S., Ottlyk, A. A.*, Electrocapillary effect on the modulus of elasticity of metals, Nature **198,** 1296 (1963).
Eden, F. X., Meyer, V., Tensile strength measurements on copper whiskers, Naturewissenschaften **47,** 352 (1960)—[Ref. 398].
Eisner, E., Fatigue straining of copper whisker, Nature **188,** 1183 (1960)—[Ref. 435].
100. *Ellis, W. C., Greiner, E. S.*, Effect of prior strain at low temperatures on the properties of some close-packed metals at room temperature, Trans. AIME **194,** 648 (1952).
Engl, J., Heidtkamp, G., Die Temperaturabhängigkeit der Kegeldruck härte der Metalle. I., Z. Physik **95,** 30 (1935)—[Ref. 442].
101. *Engle, J., Katz, J.*, Die Temperaturabhängigkeit der Kegeldruck härte der Metalle. III, Z. Physik **106,** 1 (1937).
102. *Erdmann-Jesnitzer, F.*, Effect of annealing after cold deformation on the properties of alpha-brass, Metall. **14,** 525 (1960).
103. *Everhart, J. L., Lindlief, W. E., Kanegis, J., Weissler, P. G., Siegel, F.*, Mechanical properties of metals and alloys, NBS Circ. 447, U. S. Gov.'t Printing Office, Washington, D. C., (1943).
104. *Favor, R. J., Gideon, D. N., Grover, H. J., Hayes, J. F., McClure, G. M.*, Investigation of fatigue behavior of certain alloys in the temperature range room temperature to −423 °F, Battelle Mem. Inst., WADD Tech. Rept. 61–132 (1961).
105. *Feltham, P.*, Microplasticity in metals and alloys at low temperatures, Metal Treat. Drop Forg. **20,** 221 (1961).
106. *Feltham, P.*, Creep and stress relaxation in alpha-brass at low temperatures, Phil. Mag. **6,** 259 (1961).
107. *Feltham, P.*, Stress relaxation in copper and alpha-brasses at low temperatures, J. Inst. Metals **89,** 210 (1961).
108. *Feltham, P., Copley, G. J.*, Yielding and work-hardening in alpha-brasses, Acta Met. **8,** 542 (1960).
109. *Feltham, P., Copley, G. J.*, Creep in face-centered metals and solid solutions with special reference to alpha-brasses, Phil. Mag. **5,** 649 (1960).
110. *Feltham, P., Meakin, J. D.*, Creep in face-centered cubic metals with special reference to copper, Acta Met. **7,** 614 (1959).
111. *Franks, R.*, Properties of metals at low temperature, Metals Handbook (ASM, Cleveland, Ohio, 1948), p. 204.
112. *French, R. S., Hibbard, W. R., Jr.*, Effect of solute elements on the tensile deformation of copper, Trans. AIME **188,** 53 (1950).
113. *Frost, N. E.*, Alternating stress required to propagate edge cracks in copper and nickel-chromium alloy steel plates, J. Mech. Engr. Sci. **5,** #1, 15 (1963).
114. *Frost, N. E.*, Effect of mean stress on the rate of growth of fatigue cracks in sheet materials, J. Mech. Engr. Sci. **4,** 22 (1962).
115. *Frye, J. H., Jr., Scott, J. L., Woods, J. W.*, Effect of strain and temperature on the yielding of copper and nickel, J. Metals **9,** 708 (1957).
116. *Garstone, J., Honeycombe, W. K., Greentham, G.*, Easy glide of cubic metal crystals, Acta Met. **4,** 485 (1956).
117. *Geil, G. W.*, Low temperature properties and applications of heavy non-ferrous metals and alloys (Conference on Materials and Design for Low Temperature Service, Army Engr. Res. Dev. Lab., Ft. Belvoir, Va., 1952), p. 335.
118. *Geil, G. W., Carwile, N. L.*, Tensile properties of copper, nickel, and some copper-nickel alloys at low temperatures, NBS Circ. 520, 67 (1952).
119. *Gillett, H. W., Mack, E. I.*, Notes on some endurance tests of metals, Proc. ASTM **24,** 476 (1924).

120. *Gillett, H. W.*, Impact resistance and tensile properties of metals at sub-atmospheric temperatures, ASTM Spec. Tech. Publ. 47, 5 (1941).
121. *Gillett, H. W.*, The resistance of copper and its alloys to repeated stress, Metals and Alloys **3,** 200, 236, 257, 275 (1932).
122. *Gohn, G. R., Ellis, W. C.*, The fatigue characteristics of Cu-Ni-Zn and phosphor bronze strip in bending under conditions of unsymmetrical loading, Proc. ASTM **47,** 713 (1947).
123. *Gough, H. J., Sopwith, D. G.*, Atmospheric action as a factor in fatigue of metals, J. Inst. Metals **49,** 93 (1932).
Gough, H. J., Sopwith, D. G., Some further experiments on atmospheric action in fatigue, J. Inst. Metals **56,** 551 (1935)—[Ref. 356].
124. *Gough, H. J., Sopwith, D. G.*, The resistance of some special bronzes to fatigue and corrosion-fatigue, J. Inst. Metals **60,** 143 (1937).
125. *Gough, H. J., Sopwith, D. G.*, Inert atmospheres at fatigue environments, J. Inst. Metals **72,** 415 (1946).
Graves, G. B., The mechanical properties of 63/35 hard drawn brass spring wire, Wire Industry **26,** 1089 (1959)—[Ref. 464].
Greaves, R. H., Jones, J. A., The effect of temperature on the behavior of metals and alloys in the notched-bar impact test, J. Inst. Metals **34,** 85 (1925)—[Ref. 365].
126. *Greenall, C. H., Gohn, G. R.*, Fatigue properties of non-ferrous sheet metals, Proc. ASTM **37,** 160 (1937).
Greenwood, J. N., Miller, D. R., Suiter, J. W., Intergranular cavitation in stressed metals, Acta Met. **2,** 250 (1954)—[Ref. 353].
127. *Greer, J. B., Bucknall, E. H.*, The Young's modulus of α solid solution copper-nickel-zinc alloys and the valencies of copper, nickel, and zinc, Trans. ASM **57,** 554 (1964).
128. *Grein, W.*, Toughness of structural materials at low temperatures, Chem. Ing. Tech. **33,** 739 (1961).
129. *Gross, M. R.*, Low cycle fatigue of materials for submarine construction (Marine Engr. Lab.) ASTIA Rept. AD601362 (1963).
Grishkevich, A. E., Kumin, N. F., Plastic deformation of copper extended at various temperatures and strain rate, Fiz. Metal. Metallov. **16,** 427 (1963)—[Ref. 391].
130. *Grover, H. J., Gordon, S. A., Jackson, L. R.*, Fatigue of Metals and Structures (Supt. of Documents, U.S. Gov.'t Printing Office, Washington, D. C., 1954).
131. *Guillet, L., Cournat, J.*, Sur la variation des proprietes mecaniques de quelques metaux et alliages aux basses temperatures, Rev. Metall. **19,** 215 (1922).
Guillet, L., Bernard, V., Variations de la resilience du cuivre et de quelquesuns de ses alliages en fonction de la temperature, Acad. Sci. C.R. **156,** 1899 (1913)—[Ref. 457].
132. *Haasen, P., King, A.*, Work hardening and stacking fault energy of copper alloy crystals, Z. Metallk. **51,** 722 (1960).
133. *Halford, G. R., Morrow, J. D.*, Low-cycle fatigue in torsion, Proc. ASTM **62,** 695 (1962).
134. *Haupt, G., Krisch, A.*, Notch impact strength of metals at low temperatures down to the temperature of liquid hydrogen, Naturwissenchaften **26,** 390 (1938).
135. *Hein, E., Dodd, R. A.*, Softening of strain-hardened polycrystalline copper during reversed stress fatigue and tensile fatigue, AIME **221,** 1095 (1961).
136. *Helgeland, O.*, Cyclic hardening and fatigue of copper single crystals, J. Inst. Metals **93,** 570 (1965).
137. *Herenguel, J., LeNouaille, M.*, Effect of various additions on the high temperature behavior of 70–30 brass under mechanical stress, Rev. Metall. **54,** 354 (1957).
Herenguel, J., LeNouaille, M., Einfluss ver schiedener Zusatze auf das Warmverhalten von Messing Ms 70 unter mechanischer Beanspruchung, Metall. **11,** 652 (1957)—[Ref. 369].
138. *Hibbard, W. R., Jr.*, Plastic deformation of large grained copper specimens, Metals Tech., AIME Tech. Publ. 2469 (1948).
Hikata, A., Effect of plastic deformation on ultrasonic attenuation in metals, Govt. Mechanical Lab., Japan, Rept. 39, (Oct. 1960)—[Ref. 406].
139. *Hill, W. H., Shimmin, K. D., Wilcox, B. A.*, Elevated temperature dynamic moduli of metallic materials, Proc. ASTM **61,** 890 (1961).
140. *Hirsch, P. B., Mitchell, T. E., Thornton, P. R.*, Effect of strain-rate on the flow stress of f.c.c. metals, Cambridge Univ., ASTIA Rept. #AD234224 (1959).
Hirsch, P. B., Warrington, D. H., The flow stress of aluminum and copper at high temperatures, Phil. Mag. **6,** 735 (1961)—[Ref. 409].
141. *Hodge, W.*, Some properties of certain high-conductivity copper-base alloys, Trans. AIME **208,** 408 (1957).
142. *Holm, R., Meissner, W.*, Einige Messungen uber den Fliebdruck von Metallen in tiefen Temperaturen, Z. Phys. **17,** 736 (1932).
Honma, Y., Kobayashi, S., Oya, M., Kobayasi, K., Mechanical properties of castings of yellow brasses, J. Japan Foundrymen's Soc., Imono. **32,** 908, 915 (1960)—[Ref. 404].
Hook, R. E., Adair, A. M., Spretnak, J. W., Creep testing by centrifugal-force loading, Mat. Res. Stds. **1,** 464 (1961)—[Ref. 440].
143. *Horn, D. D., Lewis, H. F.*, Property investigation of copper base alloys at ambient temperatures, ASTIA Rept. 467015 (1965).
144. *Hoyt, S. L.*, Metal Data (Reinhold Publ. Corp., New York, 1952).
Hu, L. W., Determination of the plastic stress-strain relations in tension of Nittany No. 2 brass under hydrostatic pressure, 3d U. S. Nat. Congr. Appl. Mechanics, (1958), p. 557—[Ref. 400].
Hudson, O. F., McKeown, J., The properties of copper in relation to low stresses. Pt. I. Tensile and compression tests under short-time loading, J. Inst. Metals **48,** 69 (1932)—[Ref. 368].
Hughes, G., Non-ferrous metals in railway work, J. Inst. Metals **6,** 74 (1911)—[Ref. 461].
Hukai, S., Takeuchi, K., Mechanical properties of cupro-nickel at room and high temperatures, Sumitomo Light-Metal Tech. Rept. 1, 83 (1960)—[Ref. 411].
Hukai, S., Takeuchi, K., An experimental study on the effects of environments on the fatigue strength of some copper alloys, Sumitomo Light Metal Tech. Rept. **1,** 18 (1960)—[Ref. 386].
Hundy, B. B., Strain aging in 70–30 brass, J. Inst. Metals **83,** 115 (1953-54)—[Ref. 374].
145. *Huntington, A. K.*, The effect of temperatures higher than atmospheric on tensile tests of copper and its alloys, and a comparison with wrought iron and steel, J. Inst. Metals **8,** 126 (1912).
Iitaka, I., Morooka, T., On the variation of Young's modulus of 65/35 brass resulting from cold rolling and annealing, Waseda Univ. Castings Res. Lab., Rept. #13, 29 (1962)—[Ref. 383].
Ingall, D. H., The high temperature-tensile curve: a) Effect of Rate of Heating; b) Tensile Curves of Some Brasses, J. Inst. Metals **33,** 171 (1925)—[Ref. 459].
Ingall, D. H., Experiments with some copper wire: Cohesion a function of both temperature and cold-work, J. Inst. Metals **31,** 171 (1923)—[Ref. 460].
146. *Irwin, P. L.*, Fatigue of metals by direct stress, Proc. ASTM **26,** 218 (1926).
147. *Jackson, L. R., Schwope, A. D.*, Tests of physical properties of copper (Progr. Rept. to Am. Metal Co., Ltd., Oct. 1, 1946).
148. *Jaffee, R. I., Ramsey, R. H.*, Properties of aluminum bronzes at subzero and high temperatures, Metal Progr. **54,** 57 (1948).
Jares, V., Jenicek, L., Mechanisches Verhalten von Hartgezogenem Kupferdraht unter Dauerbelastung bei erhohter Temperatur, 2d Congress, Intn. Assoc. Testing Mat., (1927), p. A17—[Ref. 465].
Jeffries, Z., Effect of temperature, deformation, and grain size on the mechanical properties of metals, Trans. AIME **60,** 474 (1919)—[Ref. 367].
Jenkins, C. H. M., Bucknell, E. H., Jenkinson, E. A., The inter-relation of age-hardening and creep performance (Pt. II), J. Inst. Metals **70,** 57 (1944)—[Ref. 371].
Jenkins, C. H. M., Bucknell, E. H., The inter-relation of age-hardening and creep performance. Part I.—The age-hardening of nickel-silicon-copper alloys, J. Inst. Metals **57,** 141 (1935)—[Ref. 451].
149. *Jenkins, W. D., Digges, T. G., Johnson, C. R.*, Tensile properties of copper, nickel and 70% copper–30% nickel and 30% copper–70% nickel alloys at high temperatures, J. Res. NBS **58,** 201 (1957).
150. *Jenkins, W. D., Johnson, C. R.*, Creep of annealed nickel, copper and two nickel-copper alloys, J. Res. NBS **60,** 173 (1958).
151. *Jenkins, W. D., Digges, T. G.*, Influence of prior strain history on the tensile properties and structure of high purity copper, J. Res. NBS **49,** 167 (1952).
152. *Jenkins, W. D., Digges, T. G.*, Creep of high purity copper, J. Res. NBS **45,** 153 (1950).
153. *Jenkins, W. D., Willard, W. N.*, Creep of cold-drawn nickel, copper, 70% nickel–30% copper, and 30% Ni–70% copper alloys, J. Res. NBS **66,** 59 (1962).
154. *Johnson, A. E., Henderson, J., Khan, B.*, Complex stress creep fracture of copper at 250° under vibratory stress, Engr. **212,** 304 (1961).
155. *Johnson, W. H., Kura, J. G.*, Mechanical and physical properties of five copper-base casting alloys, Proc. ASTM **60,** 796 (1960).
156. *Johnston, H. L., Brooks, H. E.*, Impact strength of various metals at temperatures down to 20° absolute, Ohio State Univ., ASTIA Rept. #AD 67, (1952).
157. *Jones, P. G., Moore, H. F.*, An investigation of the effect of rate of strain on the results of tension tests of metals, Proc. ASTM **40,** 610 (1940).
Jones, R. B., Phillips, V. A., Yield point phenomena in a number of commercial copper alloys and one nickel base alloy, Trans. ASM **53,** 603 (1961)—[Ref. 430].
Jungclaus, H. J., Change of the modulus of elasticity of quenched Cu at room temperature, Z. Metallk., **54,** 154 (1963)—[Ref. 375].
Ke, N. P., Strength and deformation peculiarities of binary metal whiskers, Acta Physica Sinica **19,** 807 (1963)—[Ref. 387].
158. *Keefer, D., Sosin, A.*, Effect of low temperature electron irradiation on Young's modulus of pure Cu, Appl. Phys. Lett. **3,** 185 (1963).
159. *Keefer, D., Robinson, J. C., Sosin, A.*, Modulus effects in metals after low temperature electron irradiation—I. Cu, Acta Met. **13,** 1135 (1965).
Keeler, S. P., Backofen, W. A., Plastic instability and fracture in sheets stretched over rigid punches, Trans. ASM **56,** 25 (1963)—[Ref. 444].
Keil, A., The compressive strength of some copper alloys for electrotechnical purposes, Metall. **15,** 421 (1961)—[Ref. 394].
160. *Kemsley, D. S.*, The behaviour of cold-worked copper in fatigue, J. Inst. Metals **87,** 10 (1958).
Kemsley, D. S., Paterson, M. S., The influence of strain amplitude on the work hardening of copper crystals in alternating tension and compression, Acta Met. **8,** 453, (1960)—[Ref. 446].
161. *Kennedy, A. J.*, Creep of copper under stress pulses, Nature **171,** 927 (1953).
162. *Keulegan, C. H., Houseman, M. R.*, Temperature coefficient of the moduli of metals and alloys used as elastic elements, J. Res. NBS **10,** 289 (1934).
163. *Klyavin, O. V.*, Mechanical properties of solids at a temperature of 4.2 degrees K and below. V. The effect of a preliminary plastic deformation on the mechanical properties of aluminum, copper, and nickel, Soviet Phys. Solid State **2,** 1706 (1960).

164. *Knoll, H., Macherauch, E.*, Die plastische Verformung von Kupfervielkristallen in Temperaturbereich von 90 bis 300 °K, Z. Metallk. **55,** 638 (1964).
165. *Kochendorfer, A.*, Strength and properties of deformation of metals at low temperatures, Z. Metallk. **51,** 73 (1960).
166. *Kommers, J. B.*, The static and fatigue properties of brass, Proc. ASTM **31,** 243 (1931).
167. *Konig, D., Volki, J., Schilling, W.*, Einfluss von α-Bestrahlung bei tiefer Temperatur auf die innere Reibung von hochreinem Kupfer, Phys. Stat. Solidi **7,** 577 (1964).
168. *Konig, D., Volki, J., Schilling, W.*, Influence of alpha radiation at low temperature on the elastic modulus of high purity copper, Phys. Stat. Solidi **7,** 591 (1964).
169. *Koppenaal, T. J., Fine, M. E.*, Yield points in alpha Cu-Al single crystals, Trans. AIME **221,** 1178 (1961).
Koppenaal, T. J., Neutron irradiation strengthening in copper single crystals, Phil. Mag. **10,** 1257 (1965)—[Ref. 361].
Koppenaal, T. J., Kuhlmann-Wilsdorf, D., The effect of prestressing on the strength of neutron-irradiation copper single crystals, Appl. Phys. Lett. **4,** #3, 59 (1964)—[Ref. 388].
Koppenaal, T. J., The effect of neutron irradiation on the strength of α-Cu-Al single crystals, Acta Met. **12,** 487 (1964)—[Ref. 397].
170. *Kostenetz, V. I.*, Mechanical properties of metals and alloys in tension at low temperatures, J. Tech. Phys. (USSR) **16,** 515 (1946). As quoted in Metal Progr. **55,** 82 (1949) and Chem. Abs. **41,** 1583h (1947).
171. *Koster, W., Speidel, M.*, Einfluss der Korngrobe auf die Strenkgrenge von Kupferlegierungen, Phys. Stat. Solidi **3,** K401 (1963).
172. *Köster, W., Bangert, L.*, The influence of lead upon the modulus of elasticity and upon damping of copper, silver, brass, Z. Metallk. **42,** 391 (1951).
173. *Köster, W.*, Uber die Konzentrations-und Temperaturabhängigkeit des Elastizitätsmoduls der Legierungen des Kupfers, Silbers und Goldes mit Zink und Kadmium sowie des Kupfers mit Gold, Palladium und Platin, Z. Metallk. **32,** 160 (1940).
174. *Koster, W.*, The temperature dependence of the elastic modulus of pure metals, Z. Metallk. **39,** 1 (1948).
175. *Koster, W., Rauscher, W.*, Relationships between the moduli of elasticity of binary alloys and their structure, Z. Metallk. **39,** 111 (1948).
176. *Koster, W., Speidel, M. O.*, Der Einfluss der Temperatur und der Korngröbe auf die ausgepragte steckgrenze von Kupferlegierungen, Z. Metallk. **56,** 585 (1965).
177. *Kostyuk, V. G., Ziling, K. K., Serebryakov, A. V.*, Strength of metal whisker crystals containing impurities, Soviet Phys.-Solid State **5,** 2241 (1964).
178. *Krouse, G. N.*, A high-speed fatigue testing machine and some tests of speed effect on endurance limit, Proc. ASTM **34,** 156 (1934).
179. *Krupkowski, A.*, Propriétés mécaniques de cuivre, Rev. Met. **28,** 598, 641 (1931).
180. *Krupkowski, A.*, Propriétés mécaniques de cuivre, Rev. Met. **29,** 74 (1932).
181. *Kuntze, W.*, Dependence of elastic strain coefficient of copper on the pretreatment, Nat. Advisory Comm. for Aeronautics, Tech. Memo. 1287 (1950).
182. *Kuroda, M.*, Tensile properties of copper at low temperature, Sci. Papers Inst. Phys. Chem. Res. (Tokyo) **19,** 163 (1932).
Kurov, I. E., Stepanov, V. A., Life to rupture of metals subjected to torsion, Soviet Phys.-Solid State **4,** #1, 135 (1962)—[Ref. 441].
183. *Kuroyanagi, J.*, Change in modulus of rigidity of brass wires by cold-working and subsequent annealing, J. Phys. Soc. Japan **15,** 1386 (1960).
184. *Kuroyanagi, J.*, On the relation between the change in modulus of rigidity of brass wires by cold-rolling and rolling textures, J. Phys. Soc. Japan **16,** 1019 (1961).
Kurth, A., Untersuchungen uber den Einfluss der Warme auf die Harte der Metalls, Z. Vereines Deut. Ingen. **53,** 85, 209 (1909)—[Ref. 423].
Le Chatelier, A., On the influence of hardness on the results of studies of metalle, Comm. des Methodes D'essai Materiaux de Construction **2A,** 335 (1895)—[Ref. 418].
Le Chatelier, A., On the influence of temperature on the mechanical properties of metals, Comm. des Methods D'essai des Materiaux de Construction **2A,** 317 (1895)—[Ref. 432].
185. *Lawley, A., Schuster, S.*, Tensile behavior of copper foils prepared from rolled materials, Trans. AIME **230,** 27 (1964).
Lea, F. C., The effect of temperature on some of the properties of materials, Engineering **110,** 293 (1920)—[Ref. 439].
Lea, F. C., The effect of temperature on the modulus of elasticity and other properties of metals, Proc. Inst. Civil Engrs. **209,** 394 (1920)—[Ref. 452].
Leiber, C. O., Macherarauch, E., Radiographic elasticity constants for tensile lattice deformation in the (400) plane of pure copper, Z. Metallk. **51,** 621 (1960)—[Ref. 402].
Leiber, C. O., Macherarauch, E., Work hardening and residual stress of surface layers of tensile deformed copper specimens, Z. Metallk. **52,** 196 (1961)—[Ref. 408].
186. *Lems, W.*, The change of Young's modulus of copper and silver after deformation at low temperature and its recovery, Physica **28,** 445 (1962).
187. *Lismer, R. E.*, Properties of some alloys and weld metal deposits at low temperatures, Welding Metal Fabr. **30,** 19 (1962).
188. *Lismer, R. E.*, The properties of some metals and alloys at low temperatures, J. Inst. Metals **89,** 145 (1960).
189. *Lismer, R. E.*, Copper alloys for cryogenic service. I. Metal industry (Apr. 16, 1964); II. Metal industry (Apr. 23, 1964).
190. *Lorig, C. H., Dahle, F. B., Roberts, D. A.*, The mechanical properties of copper at elevated temperatures, Metals Alloys **9,** 63 (1938).
191. *Ludwig, P.*, Uber die Anderung der inneren Reibung der Metalle mit der Temperatur, Z. Phys. Chemie **91,** 232 (1916).
Lushley, R. S. D., McKeown, J., Stress-rupture time properties of copper tube materials, Engineer **197,** 811 (1954)—[Ref. 438].
192. *MacCrone, R. K., McCammon, R. D., Rosenberg, H. M.*, The fatigue of metals at 1.7 degrees K, Phil. Mag. **4,** 267 (1959).
193. *MacGregor, C. W.*, Abstract of the true stress-strain tension test—Its role in modern materials testing, J. Franklin Inst. **238,** 111 (1944).
194. *Magnusson, A. W., Baldwin, W. M., Jr.*, The effects of stress concentration and triaxiality on the plastic flow of metals (Case Inst. Tech. Rept. 34, 1956).
195. *Makin, M. J.*, The effect of neutron irradiation on the mechanical properties of metals, Part III—Copper and nickel, Atomic Energy Res. Estb., England, ASTIA Rept. AD127685 (1956).
196. *Makin, M. J.*, Unloading effects in the plastic properties of copper single crystals, Atomic Energy Res. Estb., England, ASTIA Rept. #AD158958 (1957).
197. *Makin, M. J., Blewitt, T. H.*, The hardening of copper single crystals by electron irradiation, Acta Met. **10,** 241 (1962).
Makin, M. J., Manthorpe, S. A., Hardening of copper irradiated at −195° C, Acta Met. **9,** 886 (1961)—[Ref. 393].
Makins, N., Shidara, H., Studies of Cr-Be Copper, J. Inst. Metals, Japan **24,** 496 (1960)—[Ref. 401].
198. *Manjoine, M., Nadai, A.*, High speed tension tests at elevated temperatures, Part I, Proc. ASTM **40,** 822 (1940).
199. *Marchant, P. R.*, Mechanical properties of some wrought copper alloys at elevated temperatures, Copper (CDA), #18, 16 (1963).
200. *Marshall, E. R., Shaw, M. C.*, The determination of flow stress from a tensile specimen, Trans. ASM **44,** 705 (1952).
201. *Marsimovich, G. G., Yanchishin, F. P.*, Determination of tensile strength of metals in liquid medium, Zavodskaya Labs **28,** 1485 (1962).
202. *Martin, D. L., Parker, E. R.*, The effect of cooling rate and minor constituents on the rupture properties of copper at 200° C, Trans. AIME **156,** 126 (1944).
203. *McAdam, D. J., Jr.*, Influence of temperature on the stress-strain energy relationship for copper and nickel-copper alloy, Trans. AIME **185,** 727 (1949).
204. *McAdam, D. J., Jr.*, Corrosion-fatigue of non-ferrous metals, Proc. ASTM **27,** 102 (1927).
205. *McAdam, D. J., Jr., Geil, G. W., Woodard, D. H.*, Influence of strain rate and temperature on the mechanical properties of monel metal and copper, Proc. ASTM **46,** 902 (1946).
206. *McAdam, D. J., Jr., Clyne, R. W.*, Influence of chemically and mechanically formed notches on fatigue of metals, NBS Res. Paper RP725, **13,** (1934).
207. *McAdam, D. J., Jr.*, The stress-strain energy relationship for metals, Trans. ASM **43,** 970 (1951).
McAdam, D. J., Jr., Geil, G. W., The variation of the strength, resistance to oxidation, and electrical conductivity of metals with temperature, Trans. ASM **33,** 514 (1944)—[Ref. 366].
208. *McAdam, D. J., Jr., Geil, G. W., Cromwell, F. J.*, Flow, fracture and ductility of metals, Metals Tech., AIME Tech. Publ. 2296 (1948).
209. *McAdam, D. J., Jr., Geil, G. W., Mebs, R. W.*, Effects of combined stresses and low temperatures on the mechanical properties of some non-ferrous metals, Trans. ASM **37,** 497 (1946).
210. *McAdam, D. J., Jr., Geil, G. W., Mebs, R. W.*, The effect of combined stresses on the mechanical properties of steels between room temperature and −188° C, Proc. ASTM **45,** 448 (1945).
211. *McAdam, D. J., Jr.*, Endurance properties of alloys of nickel and of copper—Pt. 1, Trans. Am. Soc. Steel Treat. **7,** 54, 217, 581 (1925).
212. *McAdam, D. J., Jr., Mebs, R. W.*, The technical cohesive strength and other mechanical properties of metals at low temperatures, Proc. ASTM **43,** 661 (1943).
McAdam, D. J., Jr., Mebs, R. W., An investigation of the technical cohesive strength of metals, Trans. AIME **162,** 474 (1945)—[Ref. 370].
213. *McAdam, D. J. Jr., Geil, G. W., Woodard, D. H.*, Influence of the strain rate and the stress system on the mechanical properties of copper, Trans. ASM **38,** 551 (1947).
McAdam, D. J., Jr., Fatigue and corrosion-fatigue of spring material, Trans. ASME **51,** APM-51-5-45 (1929)—[Ref. 456].
McAdam, D. J., Jr., Effect of cold working on endurance and other properties of metals, Part I, Trans. Am. Soc. Steel Treat. **8,** 782 (1925)—[Ref. 436].
214. *McAdam, D. J., Jr.*, Fatigue and corrosion—Fatigue of metals, Part I (Congrés International pour L'essai des Materiaux, M. Nijhoff, Amsterdam, 1927), p. 305.
215. *McAdam, D. J., Jr.*, Endurance properties of metals, Mech. Engr. **47,** 566 (1925).
216. *McCammon, R. D., Rosenberg, H. M.*, The fatigue and ultimate tensile strengths of metals between 4.2 and 293 °K, Proc. Roy. Soc. (London) **A242,** 203 (1957).
217. *McClintock, R. M., Van Gundy, D. A. Kropschot, R. H.*, Low temperature tensile properties of copper and four bronzes, ASTM Bull. 240, 47 (1959).
218. *McClintock, R. M., Gibbons, H. P.*, Mechanical properties of structural materials at low temperatures, A compilation from the literature, NBS Mono. 13 (Supt. Documents, U.S. Govt. Printing Office, Washington, D.C., 1960).

219. *McEvily, A. J., Boettner, R. C.*, On fatigue crack propagation in F.C.C. metals, Acta Met. **11,** 725 (1963).
220. *McGrath, J. T., Thurston, R. C. A.*, The effect of cross slip on the fatigue behavior of copper and copper-zinc alloys, Trans. AIME **227,** 645 (1963).
221. *McKeown, J., Hudson, O. F.*, Stress-strain characteristics of copper, silver, and gold, J. Inst. Metals **60,** 109 (1937).
222. *McKeown, J., Mends, D. N., Bale, E. S., Michael, A. D.*, The creep and fatigue properties of some wrought complex aluminum bronzes, J. Inst. Metals **83,** 69 (1954–55).
223. *McManus, G. M.*, Elastic properties of β-CuZn, Phys. Rev. **129,** 2004 (1963).
224. *Michelitsch, M.*, Uber das Kriechen kubisch flächenzentrierter Metall-Einkristalle, Z. Metallk. **50,** 548 (1959).
225. *Midgley, P., Thomas, D. F.*, The mechanical properties of metals at cryogenic temperatures, Rocket Propulsion Estb., England, ASTIA Rept. AD272301 (1961).
226. *Mikesell, R. P., Reed, R. P.*, The impact testing of various alloys at low temperatures, *Adv. Cryogenic Engr.* **3** (Plenum Press, Inc., New York, 1960), p. 316.
227. *Mitchell, T. E., Thornton, P. R.*, The work-hardening characteristics of Cu and alpha-brass single crystals between 4.2 and 500 degrees K, Phil. Mag. **8,** 1127 (1963).
228. *Moon, D. P., Simmons, W. P.*, Creep and rupture properties of five copper-base casting alloys, Proc. ASTM **61,** 938 (1961).
229. *Moore, H. F., Jasper, T. M.*, An investigation of the fatigue of metals, Series of 1925, Univ. Illinois Engr. Bull. 152 (1925).
230. *Moore, H. F., Lewis, R. E.*, Fatigue tests in shear of three non-ferrous metals, Proc. ASTM **31,** 236 (1931).
231. *Moore, R. R.*, Resistance of metals to repeated static and impact stresses, Proc. ASTM **24,** 547 (1924).
232. *Moore, R. R.*, Some fatigue tests on non-ferrous metals, Proc. ASTM **25,** 66 (1925).
233. *Moore, R. R.*, Resistance of manganese bronze, duraluminum, and electron metal to alternating stresses, Proc. ASTM **23,** 106 (1923).
Moore, H. F., Wishart, H. B., Lyon, S. W., Slow bend and impact tests of notched bars at low temperatures, Proc. ASTM **36,** 110 (1936)—[Ref. 363].
Moore, R. R., A study of slip lines, strain lines and cracks in metals under repeated stress, Univ. Illionis Engr. Expt. Station, Bull 191 (1929)—[Ref. 454].
Morooka, T., Variation of Young's modulus of 65 : 35 brass due to rolling and annealing, Nippon Kinzoku Gakkai-Si **23,** 573 (1959)—[Ref. 412].
Moroz, L. S., Kolgatin, N. N., Teodorovich, V. P., Deryabina, V. I., Influence of hydrogen on the mechanical properties of nickel and copper, Phys. Metals Metallog. **16,** No. 5, 87 (1963)—[Ref. 385].
234. *Munse, W. H., Weil, N. A.*, Mechanical properties of copper at various temperatures, Proc. ASTM **51,** 996 (1951).
235. *Musatti, I., Dainelli, L.*, Influence of heat treatment on the fatigue and corrosion resistance of aluminum bronze, Allumino **4,** 51 (1935); Aluminum Bronze, Copper Dev. Assoc. Publ. 31.
236. *Nadai, A., Manjoine, H. J.*, High speed tension tests at elevated temperatures, Part II and III, J. Appl. Mech. **8,** 77 (1941).
Nadgornyi, E. M., Stepanov, A. V., Testing of filamentary crystals in tension and bending, Soviet Phys.—Solid State **3,** #4, 778 (1961)—[Ref. 410].
237. *Nara, T., Yamada, Y.*, Study of zone-refined high purity copper. Pt. 2. Tensile tests and room temperature recrystallization of zone-melted copper, J. Inst. Metals, Japan **24,** 744 (1960).
Nara, T., Nishihata, M., Akiyama, M., Vickers microhardness of zone refined copper, J. Inst. Metals, Japan **25,** 72 (1961)—[Ref. 407].
Nine, H. D., Discontinuities in the S–N fatigue curve of ⟨111⟩ copper single crystals, Trans. AIME **233,** 1444 (1965)—[Ref. 414].
238. *Neighbours, J. R., Smith, C. S.*, The elastic constants of copper alloys, Acta Met. **2,** 591 (1954).
239. *North American Aviation, Inc.*, Materials Property Manual and Summary Report (Internal Rept. AL–2604, Canoga Park, Calif., 1957).
240. *Novikov, A. V., Chervyakova, V. V., Presnyakov, A. A.*, Ductility of LS59–1 brass at high temperatures, Tsvetnge Metally. No. 4, 73 (1964).
241. *Novokreshchenov, P. D., Savchenko, N. V.*, Effect of low-melting-point metal coatings on the mechanical properties of metals after thermal cycling, Dokl. Acad. Nauk. (SSSR) **148,** 328 (1963).
242. *Nunes, J., Larson, F. R.*, Low temperature hardness and flow stress relationships of metals, J. Inst. Metals **91,** 114 (1962).
243. *Okuda, S.*, Dislocation relaxation peaks in F.C.C. metals after deformation at 4.2 °K, Sci. Papers, Inst. Phys. Chem. Res. (Tokyo) **57,** 116 (1964).
244. *Overton, W. C., Gaffney, J.*, Temperature variation of the elastic constants of cubic elements, 1.—Copper, Phys. Rev. **98,** 969 (1955).
245. *Packer, M. E., Wood, W. A.*, Room-temperature creep in cold-drawn copper under alternating torsion and tensile load, J. Inst. Metals **92,** 413 (1964).
246. *Panseri, C., Leoni, M., Mori, L.*, Fatigue resistance and corrosion fatigue of aluminum bronzes Xantol B and XM under cyclic bending, Alluminio **29,** 113 (1962).
247. *Parker, E. R., Ferguson, C.*, Rupture tests at 200 degrees cent. on some copper alloys, Trans. ASM **31,** 699 (1943).
248. *Parker, E. R., Ferguson, C.*, The effect of strain rate upon the tensile impact strength of some metals, Trans. ASM **30,** 68 (1942).
249. *Parker, E. R., Riisness, D. F.*, Effect of grain size and bar diameter on creep rate of copper at 200 °C, Trans. AIME **156,** 117 (1944).
250. *Parker, R. J.*, Estimation of stress-rupture properties from hot hardness tests, Metallurgia **67,** 219 (1963).
Parker, E. R., The effect of impurities on some high temperature properties of copper, Trans. ASM **29,** 269 (1941)—[Ref. 455].
251. *Pels, A. R.*, Elevated temperature properties of copper base alloys, Wire and Wire Prod. **37,** 1398 (1962).
252. *Pester, F.*, Festigkeitsprufungen an Stangen und Drahten bei tiefen Temperatures, Z. Metallk. **24,** 115 (1932).
253. *Pester, F.*, Die Festigkeitseigenschaften von elektrischen Leitungsdrahten bei tiefen Temperaturen, Z. Metallk. **22,** 261 (1930).
254. *Phillips, W. L.*, A vagary of fracture, Trans. ASM **56,** 778 (1963).
Phillips, W. L., Aluminum and copper tested in direct shear, Trans. AIME **224,** 845 (1962)—[Ref. 450].
255. *Phillips, A. J., Smith, A. A.*, Effect of time on tensile properties of hard-drawn copper wire, Proc. ASTM **36,** 263 (1936).
Piatti, L., Eigenschaften von Wukstoffen im Tieftemperaturegebeit flussiger Gase, Schweizer Archiv. **26,** 100 (1960)—[Ref. 429].
Pines, B. Ya., Sirenko, A. F., Diffusion creep rate in metals at temperatures below the melting point, Fiz. Metal. Metallov. **15,** 584 (1963)—[Ref. 389].
Pines, B. Ya., Sirenko, A. F., The calculated and empirical values of the lifetime of metals and alloys under a load, Fiz. Tverdogo Tela. **2,** No. 6, 1043 (1960)—[Ref. 445].
256. *Pines, B. Ya., Ivanov, I. G.*, High-temperature mechanical properties of alloys of the copper-nickel system, Soviet Phys.-Solid State **4,** No. 8, 1543 (1963).
257. *Pomey, G., Gunbach, M., Lajeunesse, D., Crussard, C.*, Stamping tests on thin sheets, l'Inst. Res de Siderurgie Publ. Seris A (Feb. 1962), p. 809.
258. *Pomp, A., Kirsch, A., Haupt, G.*, Kerbschlagzähigkeit legierter Stähle bei Temperaturen von +20 bis −253° (Siedetemperatur des Wasserstoffs), Mitt. Kaiser-Wilhelm-Inst. Eisenforsch., Dusseldorf **21,** 219 (1939).
259. *Porembski, C. J., Pritchard, H. R.*, Survey of literature on notch-impact resistance of wrought aluminum, copper, and magnesium base alloys at normal and subnormal temperatures, Frankford Arsenal, ASTIA Rept. 49187 (1949).
260. *Port, J. H., Blank, A. I.*, The creep characteristics of copper-nickel alloys at 300, 400, and 500F, Proc. ASTM **54,** 1038 (1954).
261. *Porter, J., Levy, J. C.*, The fatigue curves of copper, J. Inst. Metals **89,** 86, (1960).
262. *Postnikov, V. S.*, Internal friction and shear modulus of pure copper and beryllium bronze, Dokl. Akad. Nauk. (SSSR) **91,** 79 (1953).
263. *Price, W. B.*, Properties of copper and some of its important industrial alloys at elevated temperatures, Symposium on Effect of Temperature on the Properties of Metals (ASTM and ASME, Philadelphia, 1931), p. 340.
264. *Price, W. B., Bailey, R. W.*, Fatigue properties of five cold-rolled copper alloys, Trans. AIME **124,** 271 (1937).
265. *Pritchard, H. R.*, Survey of literature on the effect of testing temperature on the properties of wrought copper base alloys, Frankford Arsenal, ASTIA Rept. AD202866 (1959).
266. *Rayne, J. A.*, Elastic constants of α-brasses: Variation with solute concentration from 4.2 °K–300 °K, Phys. Rev. **115,** 63 (1959).
267. *Ramsey, R. H., Jaffee, R. I., Nekervis, R. J.*, The mechanical and physical properties of certain aluminum-bronze alloys over a temperature range of −295 °F to 1000 °F, (Battelle Mem. Inst. Rept. for AMPCO Metal Inc., 1946).
Rhines, F. N., Impurities in the common nonferrous metals, Effect of Residual Elements (Am. Soc. Metals, Cleveland, 1957), p. 28—[Ref. 426].
268. *Read, H. J., Graham, A. H.*, The elastic modulus and internal friction of electrodeposited copper, J. Electrochem. Soc. **108,** 73 (1961).
269. *Richards, J. T., Brick, R. M.*, Mechanical properties of beryllium copper at subzero temperatures, J. Metals **6,** 574 (1954).
270. *Ripling, E. J.*, Notch tensile behavior of face centered cubic metals, Proc. ASTM **56,** 662 (1956).
271. *Rittenhouse, J. B.*, Impact properties of grade 8 Al bronze at subzero temperatures (AMPCO Metal Inc., Report No. 11 A–212, 1952). Quotes unpublished Battelle Mem. Inst. and Ohio State Univ. data.
272. *Roberson, J. A., Grosskreutz, J. C.*, Fatigue of copper-zinc alloys at 100 °K, Acta Met. **11,** 795 (1963).
273. *Robin, M. F.*, The hardness of steels at low temperatures, Rev. Met. **6,** 162 (1909).
274. *Rosenberg, H. M.*, The properties of metals at low temperatures, Progress in Metal Physics **7** (Pergamon Press, New York, 1958), p. 339.
275. *Rosenfield, A. R., Averbach, B. L.*, The initial stages of plastic deformation in aluminum and copper, Acta Met. **8,** 624 (1960).
276. *Rosi, F. D.*, Surface effects on plastic properties of copper crystals, Acta Met. **5,** 348 (1957).
277. *Rostoker, W.*, Fracture of metals, Ill. Inst. Tech., ASTIA Rept. AD435021 (1963).
278. *Rovinsky, B. M., Rybakova, L. M.*, Dependence of mechanical properties on structural characteristics of metals, Fiz. Metal. Metallov. (USSR) **17,** 554 (1964).
279. *Rudeloff*, (1898), as quoted in Ref. 179.
280. *Russel, H. W.*, Effect of Low Temperatures on Metals and Alloys (ASTM and ASME, Philadelphia, Pa., 1931).
Rybakova, L. M., Nikitina, I. I., Study of the time dependence of strength of Ni-Al and Cu-Al alloys, Fiz. Metal. Metallov. (USSR), **16,** 107 (1963)—[Ref. 381].
281. *Saarivirta, M. J., Taubenblat, P. P.*, Some high temperature properties of copper-zirconium and copper-chromium high-conductivity alloys, Trans. AIME **218,** 935 (1960).
Saarivirta, M. J., High conductivity copper-rich Cu-Zr alloys, Trans. AIME **218,** 431 (1960)—[Ref. 373].

Sauerwald, V. F., Die Abhängigkeit der Härte von der Temperatur, Z. Metallk. **16,** 315 (1924)—[Ref. 424].

282. *Schoenmaker, P.*, Zerreiss- und Schlag-versuche bei tiefen Temperaturen, First Commun., New Intern. Assn. Testing Mats., Group A (1930), p. 237.
283. *Schramm, K. H.*, Data for the determination of the temperature dependence of bulk modulus of pure metals, Z. Metallk. **53,** 316 (1962).
Schwab, G.-M., Some new aspects of the strength of alloys, Trans. Faraday Soc. **45,** 385 (1949)—[Ref. 427].
Schmunk, R. E., Smith, C. S., Elastic constants of copper-nickel alloys, Acta Met. **8,** 396 (1960)—[Ref. 447].
284. *Schwartzbart, H., Brown, W. F.*, Notch-bar tensile properties of various materials and their relation to the unnotch flow curve and notch sharpness, Trans. ASM **46,** 998 (1954).
285. *Schwinning, W., Strobel, E.*, An investigation of the temperature dependence of tensile strength of copper by static and dynamic strain, Z. Metallk. **26,** 1 (1934).
286. *Schwope, A. D., Smith, K. F., Jackson, L. R.*, The comparative creep properties of several types of commercial coppers, Trans. AIME **185,** 409 (1949).
Secciani, A., Mechanical properties of irradiated solids, Mecchine **16,** 969 (1961)—[Ref. 396].
287. *Seigle, L., Brick, R. M.*, Mechanical properties of metals at low temperatures: a survey, Trans. ASM **40,** 813 (1948).
288. *Shevandin, E. M.*, An investigation of the stress-strain diagram at low temperatures, Engrs. Digest **10,** 7 (1949).
Shurkov, S. N., Das Problem der Festigkeit fester Korper, Z. Physik **213,** 183 (1960)—[Ref. 463].
289. *Siede, A., Metcalfe, A. G.*, The Fatigue Hardening of Copper, Trans. AIME **215,** 947 (1959).
290. *Simakovskiy, A. P.*, High-temperature strength of copper-chromium and copper-nickel alloys, Metall. Obrab. Metallov (USSR) **6,** 41 (1958).
Simmons, W. F., Sirois, B. J., Properties of 60–40 copper-nickel alloy at temperatures ranging up to 1050 °F, Proc. ASTM **61,** 247 (1961)—[Ref. 352].
Simmons, W. F., Sirois, B. J., Williams, D. N., Jaffee, R. I., Properties of 70–30 copper-nickel alloy at temperatures ranging up to 1050 °F, Proc. ASTM **59,** 1035 (1959)—[Ref. 355].
291. *Sinclair, G. M., Craig, W. J.*, Influence of grain size on work hardening and fatigue characteristics of alpha brass, Trans. ASM **44,** 929 (1952).
Slate, P. M. B., Billings, M. J. W., Fuller, P. J. A., The ductility of copper at high strain rates, J. Inst. Metals **94,** 236 (1965)—[Ref. 372].
292. *Smirnov, B., Chernjak, V.*, Mechanical properties of special steels and non-ferrous metals at low temperatures, Metallurgy **8,** 88 (1936), abstracted in Metallurgical Abstracts, Inst. Metals **3,** 521 (1936).
293. *Smith, A. D. N.*, The effect of small amounts of cold-work on Young's modulus of copper, Phil. Mag. **44,** 453 (1953).
294. *Smith, C. S., Wagner, R. W.*, The tensile properties of some copper alloys, Proc. ASTM **41,** 825 (1941).
295. *Smith, C. S.*, Mechanical properties of copper and its alloys at low temperatures: A review, Proc. ASTM **39,** 642 (1939).
296. *Smith, C. S.*, Proportional limit tests on copper alloys, Proc. ASTM **40,** 864 (1940).
297. *Smith, J. E.*, Tension tests of metals at strain rates up to 200 sec^{-1}, Mat. Res. Std. **3,** 713 (1963).
298. *Smithells, C. J.*, Metals Reference Book (Interscience, Inc., New York, 1949).
Sosin, A., Bienvenue, L. L., Effect of electron irradiation and subsequent thermal treatment on Young's modulus of copper, J. Appl. Phys. **31,** 249 (1960)—[Ref. 448].
299. *Spector, E. N., Rakhshtadt, A. G., Gorelik, S. W., Sagalova, T. B.*, Effect of pre-recrystallization annealing on elasticity and structure of cold rolled metals and alloys with FCC lattice, Fiz. Metal. Metallov. **17,** 445 (1964).
300. *Stevens Inst. Tech., Peirce Mem. Lab. Met.*, Studies in the behavior of certain non-ferrous metals at low temperatures (Contract DA–36–039–SC–15393), (1952).
301. *Stokes, H. J.*, Apparatus for the measurement of Young's modulus between −200 and 700 °C by transverse vibration in vacuum, J. Sci. Instr. **37,** 117 (1960).
302. *Strauss, J.*, Metals and alloys for industrial applications requiring extreme stability, Trans. Am. Soc. Steel Treat. **16,** 191 (1929).
Strauss, J., Disc. of Ref. 280, Symposium on Effect of Temperature on Metals (ASTM and ASME, Philadelphia, Pa., 1931)—[Ref. 351].
303. *Subrahmanyam, B., Krishnamurty, B. H.*, Elastic velocities and moduli of some copper base binary alloys, Indian J. Pure Appl. Phys. **1,** 185 (1963).
304. *Sumino, K., Yamamoto, M.*, Work-hardening of foil crystals of copper, J. Phys. Soc. Japan **18,** 73 (1963).
305. *Sweetland, E. D., Parker, E. R.*, Effect of surface condition on creep of some commercial metals, J. Appl. Mech. **20,** 30 (1953).
306. *Takenaka, Y.*, Fatigue of metals under repeated finite strain, Bull. Japan Soc. Mech. Engrs. **3,** No. 12, 419 (1960).
307. *Tapsell, H. J., Johnson, A. E.*, The properties of copper in relation to low stresses. The effect of cold-work, heat-treatment, and composition. Pt. II, J. Inst. Metals **40,** 89 (1932).
Tapsell, H. J., Johnson, A. E., Clenshaw, W. J., Properties of materials at high temperatures, 6.—The strength at high temperatures of six steels and three non-ferrous metals, Dept. Sci. Indust. Res., Engr. Res. Bd., Spec. Rept. 18, London, Great Britain (1932—[Ref. 421].
308. *Tarr, A. L., Osborn, J. M., White, A. C.*, Properties of metallic materials at low temperatures (U.S. Army Engr. Corps. Engr. Center, Fort Belvoir, Va., 1956).
309. *Teed, P. L.*, Aircraft metallic materials under low temperature conditions, Royal Aero. Soc. (1951), p. 61.
310. *Teed, P. L.*, The Properties of Metallic Materials at Low Temperatures, Vol. I, (John Wiley & Sons, Inc., New York, 1950).
Terry, C. A., Taylor, E. A., Welding of cupro-nickel and aluminum-bronze alloys, J. Brit. Welding **5,** 211 (1958)—[Ref. 358].
Thiruvengadem, A., High frequency fatigue of metals and their cavitation damage resistance, Hydronautics, Inc., ASTIA Rept. AD456365 (1964)—[Ref. 357].
311. *Thompson, D. O., Holmes, D. K.*, Dislocation contribution to the temperature dependence of the internal friction and Young's modulus of copper, J. Appl. Phys. **30,** 525 (1959).
312. *Thompson, D. O., Paré, V. K.*, Effect of fast neutron bombardment at various temperatures upon the Young's modulus and internal friction of copper, J. Appl. Phys. **31,** 528 (1960).
Thompson, N., Recent work on the nature of fatigue damage, Symposium on Fatigue (Intn. Conf. Czechoslovak Sci.-Tech.-Soc., Prague, 1961) p. 84—[Ref. 379].
313. *Tietz, T. E., Dorn, J. E.*, Creep of copper at intermediate temperatures, Trans. AIME **206,** 156 (1956).
Titchener, A. L., Davies, G. J., Yield phenomena in polycrystalline copper, Phil. Mag. **10,** 1225 (1965)—[Ref. 360].
314. *Townsend, J. R., Greenall, C. H.*, Fatigue studies of non-ferrous metals, Proc. ASTM **29,** 353 (1929).
Tsobkallo, S. O., Vashchenko, Z. A., Effect of plastic deformation and annealing on the elastic properties of L62 brass, Metallov. i. Term. Obrab. Metal. **10,** 38 (1959)—[Ref. 417].
315. *Turnbow, J. W., Ripperger, E. A.*, Strain-rate effects on stress-strain characteristics of aluminum and copper (Proc. Fourth Midwestern Conf. on Solid Mechanics, U. Texas, 1959) p. 415.
Unckel, H., Mechanical properties of two-phase alloys as affected by microstructure, Pt. I., Z. Metallk. **54,** 525 (1963)—[Ref. 384].
Unwin, W. C., The Testing of Materials of Construction (Longmans, Greenard Co., New York, 1888) p. 339—[Ref. 422].
316. *Upthegrove, C., Burghoff, H. L.*, Elevated temperature properties of copper and copper base alloys, ASTM-ASME Joint Comm. on the Effect of Temperature on the Properties of Metals, ASTM Spec. Tech. Publ. 181 (1956).
317. *Upthegrove, C., White, A.*, Available data on the properties of non-ferrous metals and alloys at various temperatures, Proc. ASTM **24,** 88 (1924).
318. *Uzhik, G. V.*, Strength and plasticity of metals at low temperatures, Natl. Lending Libr. Sci. Tech., Boston Spa., Yorkshire (1961). Translated from Izdatel'stro Akad. Nauk. (SSSR) Moskva, (1957).
319. *Vitman, F. F., Ivanov, M. I., Joffe, B. S.*, Tensile strength of ductile metals under sudden load, Fiz. Met. Metallov. **18,** 717 (1964).
320. *Voce, E.*, The mechanical properties, including creep of aluminum bronzes at elevated temperatures, Metallurgia **35,** 3 (1946).
Volkohon, H. M., Primatova, L. V., Relationship between tensile strength and hardness at high temperatures, Zavodskaya Labs. **25,** 858 (1960)—[Ref. 415].
Vosskuhler, H., Das Zeitstandverhalten des reinen und niedriglegierten Kupfers (Literaturubersicht), Metall. **46,** 525 (1955)—[Ref. 437].
321. *Vosskuhler, H.*, Creep behavior of wrought copper-nickel alloys (Lit. Survey VI), Metall. **14,** 1081 (1960).
322. *Vosskuhler, H.*, Das Zeitstandverhalten des gekneteten Messings (Pt. III), Metall. **11,** 193 (1957).
323. *Vosskuhler, H.*, Das Zeitstandverhalten des gekneteten Sondermessinge (Lit. Survey IV), Metall. **11,** 944 (1957).
324. *Vosskuhler, H.*, Das Zeitstandverhalten des reinen und niedriglegierten Kupfers (Lit. Survey II), Metall. **10,** 1020 (1956).
Vosskuhler, H., Das Zeitstandverhalten der gekneteten Aluminiumbronzen und Mehrstoff-Aluminiumbronzen (Lit. Survey V), Metall. **13,** 1017 (1959)—[Ref. 419].
325. *Wadsworth, N. J.*, Work hardening of copper crystals under cyclic straining, Acta Met. **11,** 663 (1963).
326. *Wadsworth, N. J.*, The effect of environment on metal fatigue, Proc. of Symposium on Internal Stresses and Fatigue in Metals (Elsevier Publ. Co., New York, 1959), p. 382.
327. *Waldorf, D. L.*, Temperature and composition dependence of the elastic constants of dilute alloys of manganese in copper, Phys. Chem. Solids **16,** 90 (1960).
328. *Warren, K. A., Reed, R. P.*, Tensile and impact properties of selected materials from 20 to 300 °K, NBS Mono. 63 (U. S. Govt. Printing Office, Washington, D. C., 1963).
329. *Waterhouse, H.*, Tensile and impact properties of die casting alloys at various temperatures, Pt. 1, Advisory Comm. (Die Casting) Ministry of Supply, England, ASTIA Rept. AD159071 (1958).
330. *Watson, J.*, Properties of engineering materials at extreme subzero temperatures with supplementary information on liquid hydrogen, Convair Astron. Report EMG-44 (1958).
331. *Weibull, W.*, Scatter of fatigue life and fatigue strength in aircraft structural materials and parts, Aeron. Res. Inst., Sweden, ASTIA Rept. AD217372 (1956).
332. *Weill-Couly, P.*, Comportement des toles soudees et non-soundees on cupro-aluminums a la temperature de l'azoto liquid (−196.4 °C), Cuivre Laitons Alliages, No. 78, 3 (1964).

333. *Wellinger, K., Seufert W.*, Untersuchungen uber das Festigkeitsverhalten Metallischer Workstoffe bei tiefen Temperatures (Research on the strength properties of metals at low temperatures), Z. Metallk. **41,** 317 (1950).
334. *Welter, I. G.*, Ermudung durch kritische statische Dauerbelastung, Z. Metallk. **20,** 51 (1928).
Welter, G., Statische Dauerfestigkeit von Metallen und Legierungen, Z. Metallk. **18,** 75, 117 (1926)—[Ref. 458].
335. *Wessel, E. T.*, Some exploratory observations of the tensile properties of metals at very low temperatures, Westinghouse Res. Labs., Sci. Paper 8-0103-P1 (1956).
Westbrook, J. H., Microhardness testing at high temperatures, Proc. ASTM **57,** 873 (1957)—[Ref. 359].
336. *White, A. E., Clark, C. L.*, Discussion on properties of copper and its alloys, Symposium on Effect of Temperature on the Properties of Metals (ASTM and ASME, Philadelphia, Pa., 1931), p. 365.
White, A. E., Clark, C. L., Influence of grain size on the high temperature characteristics of ferrous and nonferrous alloys, Trans. ASM **26,** 1069 (1934)—[Ref. 420].
337. *White, A. E., Siebert, C. A.*, Literature Survey on the Low Temperature Properties of Metals (J. W. Edwards, Inc., Ann Arbor, Mich., 1947).
338. *Whitwham, D., Lequet, R., Herenquel, J.*, Annealing of 70/30 brass, Mem. Scient. Rev. Metal **57,** 809 (1960).
339. *Wilkins, R. A., Bunn, E. S.*, Copper Base Alloys (McGraw-Hill Book Co., Inc., New York, 1943).
340. *Witzig, W. F.*, Creep of copper under deuteron bombardment, J. Appl. Phys. **23,** 1263 (1952).
341. *Wolff, R. P., Dodd, R. A.*, Fatigue properties of some age-hardened alloys, Mat. Res. Std. **3,** 734 (1963).
342. *Wood, W. A.*, Metal fatigue in torsion at large and intermediate amplitudes, J. Inst. Metals **91,** 225 (1963).
343. *Wood, W. A., Bendler, H. M.*, Effect of superimposed static tension on the fatigue processes in copper subjected to alternating torsion, Trans. AIME **224,** 18 (1962).
344. *Wood, W. A., Reimann, W. H.*, Extension of copper and brass under tension and cyclic torsion, Columbia Univ., ASTIA Rept. AD465537 (1965).
345. *Wright, J. C.*, Effects of irradiation on non-fissile metals, Metallurgy in Nuclear Power Technology (Prentice-Hall, Inc., Englewood Cliffs, N. J., 1962), p. 147.
346. *Yampolski, B. Ya., Amfiteatrova, T. A.*, Investigation of the deformation of metals under low stresses on some regularities of creep in copper and aluminum, Fiz. Metal. Metallov. (USSR) **4,** 131 (1957).
Yoshida, S., Tazaki, K., Tanisawa, H., Mizuta, K., Mechanical properties of castings of phosphor bronzes, J. Japan Foundrymen's Soc., Imono. **32,** 940 (1960)—[Ref. 405].
Young, F. W., On the yield stress of copper crystals, J. Appl. Phys. **33,** 963 (1962)—[Ref. 431].
Zakharov, A. I., Effect of neutron bombardment on the elastic modulus and internal friction of copper, Fiz. Metal. Metallov. **13,** 241 (1962)—[Ref. 392].
347. *Zambrow, J. L., Fontana, M. G.*, Mechanical properties, including fatigue, of aircraft alloys at very low temperatures, Trans. ASM **41,** 480 (1949).
348. *Zetzsche, A., Hauser, O.*, Investigations on the E modulus of cold worked copper, Intern. Symp. Pure Materials in Sci. and Tech., Dresden (1961, 1963), p. 267.
349. *Zetzsche, A., Hauser, O.*, Investigations of the Young's modulus of copper after cold-working and irradiation, Zentralinstitut fur Kernphysik, Dresden, Rept. (ZFK-WF17), 1962.
350. *Zimmerli, F. P., Wood, W. P., Wilson, G. D.*, The effect of temperature upon the torsional modulus of spring materials, Proc. ASTM **30,** 350 (1930).
351. *Strauss, J.*, Disc. of Ref. 280, Symposium on Effect of Temperature on Metals, (ASTM and ASME, Philadelphia, Pa., 1931).
352. *Simmons, W. F., Sirois, B. J.*, Properties of 60-40 copper nickel alloy at temperatures ranging up to 1050 F, Proc. ASTM **61,** 247 (1961).
353. *Greenwood, J. N., Miller, D. R., Suiter, J. W.*, Intergranular Cavitation in stressed metals, Acta Met. **2,** 250 (1954).
354. *Diehl, J., Berner, R.*, Temperaturabhangigkeit der Verfestigung von Kupfer—Einkristallen oberhalb 78 °K, Z. Metallk. **51,** 522 (1960).
355. *Simmons, W. F., Sirois, B. J., Williams, D. N., Jaffee, R. I.*, Properties of 70-30 copper-nickel alloy at temperatures ranging up to 1050 °F, Proc. ASTM **59,** 1035 (1959).
356. *Gough, H. J., Sopwith, D. G.*, Some further experiments on atmospheric action in fatigue, J. Inst. Metals **56,** 551 (1935).
357. *Thiruvengadem, A.*, High frequency fatigue of metals and their cavitation damage resistance, Hydronautics, Inc., ASTIA Rept. AD456365 (1964).
358. *Terry, C. A., Taylor, E. A.*, Welding of cupro-nickel and aluminum-bronze alloys, J. Brit. Welding **5,** 211 (1958).
359. *Westbrook, J. H.*, Microhardness testing at high temperatures, Proc. ASTM **57,** 873 (1957).
360. *Titchener, A. L., Davies, G. J.*, Yield phenomena in polycrystalline copper, Phil. Mag. **10,** 1225 (1965).
361. *Koppenaal, T. J.*, Neutron irradiation strengthening in copper single crystals, Phil. Mag. **10,** 1257 (1965).
362. *Blank, A. I., Burghoff, H. L.*, Creep characteristics of phosphorized copper (0.019 per cent P) at 300, 400, and 500 F, Proc. ASTM **51,** 981 (1951).
363. *Moore, H. F., Wishart, H. B., Lyon, S. W.*, Slow bend and impact tests of notched bars at low temperatures, Proc. ASTM **36,** 110 (1936).
364. *Alers, G. A., Zimmermun, J. E.*, Dislocation mobility in f.c.c. metals below 1 °K, Phys. Rev. **139,** A414 (1965).
365. *Greaves, R. H., Jones, J. A.*, The effect of temperature on the behaviour of metals and alloys in the notched-bar impact test, J. Inst. Metals **34,** 85 (1925).
366. *McAdam, D. J., Jr., Geil, G. W.*, The variation of the strength, resistance to oxidation, and electrical conductivity of metals with temperature, Trans. ASM **33,** 514 (1944).
367. *Jeffries, Z.*, Effect of temperature, deformation, and grain size on the mechanical properties of metals, Trans. AIME **60,** 474 (1919).
368. *Hudson, O. F., McKeown, J.*, The properties of copper in relation to low stresses. Pt. I. Tensile and compression tests under short-time loading, J. Inst. Metals **48,** 69 (1932).
369. *Herenquel, J., LeNouaille, M.*, Einfluss ver schiedener Zusatze auf das Warmverhalten von Messing Ms 70 unter mechanischer Beanspruchung, Metall. **11,** 652 (1957).
370. *McAdum, D. J., Jr., Mebs, R. W.*, An investigation of the technical cohesive strength of metals, Trans. AIME **162,** 474 (1945).
371. *Jenkins, C. H. M., Bucknall, E. H., Jenkinson, E. A.*, The interrelation of age-hardening and creep performance. (Pt. II.) J. Inst. Metals **70,** 57 (1944).
372. *Slate, P. M. B., Billings, M. J. W., Fuller, P. J. A.*, The ductility of copper at high strain rates, J. Inst. Metals **94,** 236 (1965).
373. *Saarivirta, M. J.*, High conductivity copper-rich Cu-Zr alloys, Trans. AIME **218,** 431 (1960).
374. *Hundy, B. B.*, Strain aging in 70-30 brass, J. Inst. Metals **82,** 115 (1953-54).
375. *Jungclaus, H. J.*, Change of the modulus of elasticity of quenched Cu at room temperature, Z. Metallk. **54,** 154 (1963).
376. *Benson, N. D., McKeown, J., Mends, D. N.*, The creep and softening properties of copper for alternator rotor windings, J. Inst. Metals **80,** 131 (1951).
377. *Dennison, J. P.*, Some creep characteristics of a group of precipitation hardening alloys based on the alpha copper-aluminum phase, J. Inst. Metals **82,** 117 (1953-54).
378. *Dennison, J. P.*, Creep behavior at 300 °C of a group of precipitation-hardening alloys based on the alpha copper-aluminum phase, J. Inst. Metals **83,** 465 (1954-55).
379. *Thompson, N.*, Recent work on the nature of fatigue damage, Symposium on Fatigue (Intn. Conf. Czechoslovak Sci.-Tech.-Soc., Prague, 1961), p. 84.
380. *Beresnev, B. I., Balychev, D. K.*, Mechanical properties of Al and Cu after high-pressure extruding, Fiz. Metal. Metallov. (USSR) **16,** 177 (1963).
381. *Rybakova, L. M., Nikitina, I. I.*, Study of the time dependence of strength of Ni-Al and Cu-Al alloys, Fiz. Metal. Metallov. (USSR). **16,** 107 (1963).
382. *Diehl, J.*, Influence of neutron irradiation on the mechanical properties of face-centered cubic crystals, Radiation Damage in Solids (Intn. Publ. Inc., New York, 1962), p. 129.
383. *Iitaka, I., Morooka, T.*, On the variation of Young's modulus of 65-35 brass resulting from cold rolling and annealing, Waseda Univ. Castings Res. Lab. Rept 13, 29 (1962).
384. *Unckel, H.*, Mechanical properties of two-phase alloys as affected by microstructure, Pt. I., Z. Metallk. **54,** 525 (1963).
385. *Moroz, L. S., Kolgatin, N. N., Teodorovich, V. P., Deryabina, V. I.*, Influence of hydrogen on the mechanical properties of nickel and copper, Phys. Metals Metallog. **16,** No. 5, 87 (1963).
386. *Hukai, S., Takeuchi, K.*, An experimental study on the effects of environments on the fatigue strength of some copper alloys, Sumitomo Light Metal Tech. Rept. **1,** 18, (1960).
387. *Ke, N. P.*, Strength and deformation pecularities of binary metal whiskers, Acta Physica Sinica **19,** 807 (1963).
388. *Koppenaal, T. J., Kuhlmann-Wilsdorf, D.*, The effect of prestressing on the strength of neutron-irradiation copper single crystals, Appl. Phys. Lett. **4,** No. 3, 59 (1964).
389. *Pines, B. Ya., Sirenko, A. F.*, Diffusion creep rate in metals at temperatures below the melting point, Fiz. Metal. Metallov. **15,** 584 (1963).
390. *Bystrov, L. N., Ivanov, L. I., Prokoshkin, D. A.*, Creep of copper and copper-nickel alloys during torsion, Izvest. Akad Nauk (SSSR), Met. i Topl. **5,** 197 (1962).
391. *Grishkevich, A. E., Kumin, N. F.*, Plastic deformation of copper extended at various temperatures and strain rate, Fiz. Metal. Metallov. **16,** 427 (1963).
392. *Zakharov, A. I.*, Effect of neutron bombardment on the elastic modulus and internal friction of copper, Fiz. Metal. Metallov. **13,** 241 (1962).
393. *Makin, M. J., Manthorpe, S. A.*, Hardening of copper irradiated at −195 °C, Acta Met. **9,** 886 (1961).
394. *Keil, A.*, The compressive strength of some copper alloys for electrotechnical purposes, Metall. **15,** 421 (1961).
395. *Blewitt, T. H.*, Low temperature irradiation studies, Proc. Intn. School Physics, E. Fermi Course XVIII (Radiation Damage in Solids, Academic Press, New York, 1962), p. 630.
396. *Secciani, A.*, Mechanical properties of irradiated solids, Mecchine **16,** 969 (1961).
397. *Koppenaal, T. J.*, The effect of neutron irradiation on the strength of α-Cu-Al single crystals, Acta Met. **12,** 487 (1964).
398. *Eden, F. X., Meyer, V.*, Tensile strength measurements on copper whiskers, Naturewissenschaften **47,** 352 (1960).
399. *Bovet, H.*, Zirconium alloyed copper, Pro-Metal **13,** 375 (1960).

400. *Hu, L. W.*, Determination of the plastic stress-strain relations in tension of Nittany No. 2 brass under hydrostatic pressure, 3d U. S. Nat. Congr. Appl. Mechanics, (1958), p. 557.
401. *Makins, N., Shidara, H.*, Studies of Cr-Be copper, J. Inst. Metals, Japan **24,** 496 (1960).
402. *Leiber, C. O., Macherarauch, E.*, Radiographic elasticity constants for tensile lattice deformation in the (400) plane of pure copper, Z. Metallk. **51,** 621 (1960).
403. *Baron, V. V. Savitskii, E. M.*, The effect of temperature on the strength of brittle metallic substances, Dokl. Acad. Nauk. (SSSR) **94,** 269 (1954).
404. *Honma, Y., Kobayashi, S., Oya, M., Kobayasi, K.*, Mechanical properties of castings of yellow brasses, J. Japan Foundrymen's Soc., Imono. **32,** 908, 915 (1960).
405. *Yoshida, S., Tazaki, K., Tanisawa, H., Mizuta, K.*, Mechanical properties of castings of phosphor bronzes, J. Japan Foundrymen's Soc., Imono. **32,** 940 (1960).
406. *Hikata, A.*, Effect of plastic deformation on ultrasonic attenuation in metals, Govt. Mechanical Lab., Japan, Rept. No. 39, (Oct. 1960).
407. *Nara, T., Nishihata, M., Akiyama, M.*, Vickers microhardness of zone refined copper, J. Inst. Metals, Japan **25,** 72 (1961).
408. *Leiber, C. O., Macherarauch, E.*, Work hardening and residual stress of surface layers on tensile deformed copper specimens, Z. Metallk. **52,** 196 (1961).
409. *Hirsch, P. B., Warrington, D. H.*, The flow stress of aluminum and copper at high temperatures, Phil. Mag. **6,** 735 (1961).
410. *Nadgornyi, E. M., Stepanov, A. V.*, Testing of filamentary crystals in tension and bending, Soviet Phys.–Solid State **3,** No. 4, 778 (1961).
411. *Hukai, S., Takeuchi, K.*, Mechanical properties of cupro-nickel at room and high temperatures, Sumitomo Light-Metal Tech. Rept. **1,** 83 (1960).
412. *Morooka, T.*, Variation of Young's modulus of 65-35 brass due to rolling and annealing, Nippon Kinzoku Gakkai-Si **23**, 573 (1959).
413. *Amfiteatrova, T. A., Yampol'sky, B. Ya.*, Deformation of metals at low stresses. II.—Influence of adsorption-active media on creep of copper and aluminum, Phys. Metals Metallog. **7,** No. 5, 130 (1959).
414. *Nine, H. D.*, Discontinuities in the S-N fatigue curve of ⟨111⟩ copper single crystals, Trans. AIME **233,** 1444 (1965).
415. *Volkohon, H. M., Primatova, L. V.*, Relationship between tensile strength and hardness at high temperatures, Zavodskaya Labs. **25,** 858 (1960).
416. *Davenport, C. C.*, Correlation of creep and relaxation properties of copper, Trans. ASME **60,** A–55 (1938).
417. *Tsobkallo, S. O., Vashchenko, Z. A.*, Effect of plastic deformation and annealing on the elastic properties of L62 brass, Metallov. i. Term. Obrab. Metal. No. 10, 38 (1959).
418. *Le Chatelier, A.*, On the influence of hardness on the results of studies of metals, Comm. des Methodes d'Essai Materiaux de Construction **2A,** 335 (1895).
419. *Vosskuhler, H.*, Das Zeitstandverhalten der gekneteten Aluminiumbronzen und mehrstoff-Aluminiumbronzen (Lit. Survey V), Metall. **13,** 1017 (1959).
420. *White, A. E. Clark, C. L.*, Influence of grain size on the high temperature characteristics of ferrous and nonferrous alloys, Trans. ASM **26,** 1069 (1934).
421. *Tapsell, H. J., Johnson, A. E., Clenshaw, W. J.*, Properties of materials at high temperatures. 6. The strength at high temperatures of six steels and three nonferrous metals, Dept. Sci. Indust. Res., Engr. Res. Bd., Spec. Rept. No. 18, London, Great Britain (1932).
422. *Unwin, W. C.*, The Testing of Materials of Construction, (Longmans, Greenard Co., New York, 1888), p. 339.
423. *Kurth, A.*, Untersuchungen über den Einfluss der Warme auf die Harte der Metalls, Z. Vereines Deut. Ingen. **53,** 85, 209 (1909).
424. *Sauerwald, V. F.*, Die Abhängigkeit der Härte von der Temperatur, Z. Metallk. **16,** 315 (1924).
425. *Donachie, M. J., Steele, R. K., Shepheard, P. G.*, Elevated-temperature behavior of annealed 70-30 copper-nickel, Proc. ASTM **63,** 598 (1963).
426. *Rhines, F. N.*, Impurities in the common nonferrous metals, Effect of Residual Elements (Am. Soc. Metals, Cleveland, 1957), p. 28.
427. *Schwab, G.-M.*, Some new aspects of the strength of alloys, Trans. Faraday Soc. **45,** 385 (1949).
428. *Blatherwick, A. A., Mowbray, D. F.*, Stress-strain relationships in low- and intermediate-cycle fatigue, Proc. ASTM **64,** 561 (1964).
429. *Piatti, L.*, Eigenschaften von Wukstoffen im Tieftemperaturegebeit flussiger Gase, Schweizer Archiv. **26,** 100 (1960).
430. *Jones, R. B., Phillips, V. A.*, Yield point phenomena in a number of commercial copper alloys and one nickel base alloy, Trans. ASM **53,** 603 (1961).
431. *Young, F. W.*, On the yield stress of copper crystals, J. Appl. Phys. **33,** 963 (1962).
432. *Le Chatelier, A.*, On the influence of temperature on the mechanical properties of metals, Comm. des Methodes d'Essai des Materiaux de Construction **2A,** 317 (1895).
433. *Adams, M. A., Higgins, P. R. B.*, The hardening of copper by neutron irradiation, Phil. Mag. **4,** 777 (1959).
434. *Bendler, H. M., Nine, H. D.*, Fatigue failure in copper single crystals at low and high amplitudes of torsion, Nature **194,** 1069 (1962).
435. *Eisner, E.*, Fatigue straining of copper whisker, Nature **188,** 1183 (1960).
436. *McAdam, D. J., Jr.*, Effect of cold working on endurance and other properties of metals, Part I., Trans. Am. Soc. Steel Treat. **8,** 782 (1925).
437. *Vosskuhler, H.*, Das Zeitstandverhalten des reinen und niedriglegierten Kupfers (Literaturubersicht), Metall. **46,** 525 (1955).
438. *Lushley, R. S. D., McKeown, J.*, Stress-rupture time properties of copper tube materials, Engineer **197,** 811 (1954).
439. *Lea, F. C.*, The effect of temperature on some of the properties of materials, Engineering **110,** 293 (1920).
440. *Hook, R. E., Adair, A. M., Spretnak, J. W.*, Creep testing by centrifugal-force loading, Met. Res. Stds. **1,** 464 (1961).
441. *Kurov, I. E., Stepanov, V. A.*, Life to rupture of metals subjected to torsion, Soviet Phys.—Solid State **4,** No. 1, 135 (1962).
442. *Engl, J., Heidtkamp, G.*, Die Temperaturabhangigkeit der Kegeldruck härte der Metalle. I., Z. Physik **95,** 30 (1935).
443. *Barrett, C. R., Sherby, O. D.*, Steady-state creep characteristics of polycrystalline copper in the temperature range 400° to 950 °C, Trans. AIME **230,** 1322 (1964).
444. *Keeler, S. P., Backofen, W. A.*, Plastic stability and fracture in sheets stretched over rigid punches, Trans. ASM **56,** 25 (1963).
445. *Pines, B. Ya., Sirenko, A. F.*, The calculated and empirical values of the lifetime of metals and alloys under a load, Fiz. Tverdogo Tela **2,** No. 6, 1043 (1960).
446. *Kemsley, D. S., Paterson, M. S.*, The influence of strain amplitude on the work hardening of copper crystals in alternating tension and compression, Acta Met. **8,** 453 (1960).
447. *Schmunk, R. E., Smith, C. S.*, Elastic constants of copper-nickel alloys, Acta Met. **8,** 396 (1960).
448. *Sosin, A., Bienvenue, L. L.*, Effect of electron irradiation and subsequent thermal treatment on Young's modulus of copper, J. Appl. Phys. **31,** 249 (1960).
449. *Bregowsky, I. M., Spring, L. W.*, The effect of high temperatures on the physical properties of some alloys (Proc. (Pt. II) Intn. Assoc. Testing Mat., 6th Congr., New York, 1912), Section VII.
450. *Phillips, W. L.*, Aluminum and copper tested in direct shear, Trans. AIME **224,** 845 (1962).
451. *Jenkins, C. H. M., Bucknall, E. H.*, The inter-relation of age-hardening and creep performance. Part I. The age-hardening of nickel-silicon-copper alloys, J. Inst. Metals **57,** 141 (1935).
452. *Lea, F. C.*, The effect of temperature on the modulus of elasticity and other properties of metals, Proc. Inst. Civil Engrs. **209,** 394 (1920).
453. *Coffin, L. F.*, Low cycle fatigue, ASM Metals Eng., Quart. **56,** 15 (1963).
454. *Moore, R. R.*, A study of slip lines, strain lines, and cracks in metals under repeated stress, Univ. Illinois Engr. Expt. Station, Bull. 191 (1929).
455. *Parker, E. R.*, The effect of impurities on some high temperature properties of copper, Trans. ASM **29,** 269 (1941).
456. *McAdam, D. J., Jr.*, Fatigue and corrosion—Fatigue of spring materials, Trans. ASME **51,** APM–51–5–45 (1929).
457. *Guillet, L., Bernard, V.*, Variations de la resilence du cuivre et de quelquesuns de se alliages en fonction de la temperature, Acad. Sci. C.R. **156,** 1899 (1913).
458. *Welter, G.*, Statische Dauerfestigkeit von Metallen und Legierungen, Z. Metallk. **18,** 75, 117 (1926).
459. *Ingall, D. H.*, The high temperature-tensile curve: (a) Effect of rate of heating; (b) Tensile curves of some brasses, J. Inst. Metals **33,** 171 (1925).
460. *Ingall, D. H.*, Experiments with some copper wire: Cohesion a function of both temperature and cold-work, J. Inst. Metals **31,** 171 (1923).
461. *Hughes, G.*, Non-ferrous metals in railway work, J. Inst. Metals **6,** 74 (1911).
462. *Frost, N. E.*, Effect of mean stress on the rate of growth of fatigue cracks in sheet materials, J. Mech. Engr. Sci. **4,** 22 (1962).
463. *Shurkov, S. N.*, Das Problem der festigkeitfester Korper, Z. Physik **213,** 183 (1960).
464. *Graves, G. B.*, The mechanical properties of 63-65 hard drawn brass spring wire, Wire Industry **26,** 1089 (1959).
465. *Jares, V., Jenicek, L.*, Mechanisches Verhalten von hartgezogenem Kupferdraht unter Dauerbelastung bei erholter Temperatur, 2d Congress, Intn. Assoc. Testing Mat., (1927), p. A17.

NBS TECHNICAL PUBLICATIONS

PERIODICALS

● **JOURNAL OF RESEARCH** reports National Bureau of Standards research and development in physics, mathematics, chemistry, and engineering. Comprehensive scientific papers give complete details of the work, including laboratory data, experimental procedures, and theoretical and mathematical analyses. Illustrated with photographs, drawings, and charts.

Published in three sections, available separately:

● **Physics and Chemistry**

Papers of interest primarily to scientists working in these fields. This section covers a broad range of physical and chemical research, with major emphasis on standards of physical measurement, fundamental constants, and properties of matter. Issued six times a year. Annual subscription: Domestic, $5.00; foreign, $6.00*.

● **Mathematics and Mathematical Physics**

Studies and compilations designed mainly for the mathematician and theoretical physicist. Topics in mathematical statistics, theory of experiment design, numerical analysis, theoretical physics and chemistry, logical design and programming of computers and computer systems. Short numerical tables. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75*.

● **Engineering and Instrumentation**

Reporting results of interest chiefly to the engineer and the applied scientist. This section includes many of the new developments in instrumentation resulting from the Bureau's work in physical measurement, data processing, and development of test methods. It will also cover some of the work in acoustics, applied mechanics, building research, and cryogenic engineering. Issued quarterly. Annual subscription: Domestic, $2.75; foreign, $3.50*.

● **TECHNICAL NEWS BULLETIN**

The best single source of information concerning the Bureau's research, developmental, cooperative and publication activities, this monthly publication is designed for the industry-oriented individual whose daily work involves intimate contact with science and technology—*for engineers, chemists, physicists, research managers, product-development managers, and company excutives.* Annual subscription: Domestic, $1.50; foreign, $2.25*.

* Difference in price is due to extra cost of foreign mailing.

NONPERIODICALS

Applied Mathematics Series. Mathematical tables, manuals, and studies.

Building Science Series. Research results, test methods, and performance criteria of building materials, components, systems, and structures.

Handbooks. Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Miscellaneous Publications. Charts, administrative pamphlets, Annual reports of the Bureau, conference reports, bibliographies, etc.

Monographs. Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

National Standard Reference Data Series. NSRDS provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated.

Product Standards. Provide requirements for sizes, types, quality and methods for testing various industrial products. These standards are developed cooperatively with interested Government and industry groups and provide the basis for common understanding of product characteristics for both buyers and sellers. Their use is voluntary.

Technical Notes. This series consists of communications and reports (covering both other agency and NBS-sponsored work) of limited or transitory interest.

CLEARINGHOUSE

The Clearinghouse for Federal Scientific and Technical Information, operated by NBS, supplies unclassified information related to Government-generated science and technology in defense, space, atomic energy, and other national programs. For further information on Clearinghouse services, write:

Clearinghouse
U.S. Department of Commerce
Springfield, Virginia 22151

Order NBS publications from:
Superintendent of Documents
Goverment Printing Office
Washington, D.C. 20402

U.S. GOVERNMENT PRINTING OFFICE : 1967 OL—261-278